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(54) **CATHETERS WITH NON-REMOVABLE GUIDE MEMBERS USEABLE FOR TREATMENT OF SINUSITIS**

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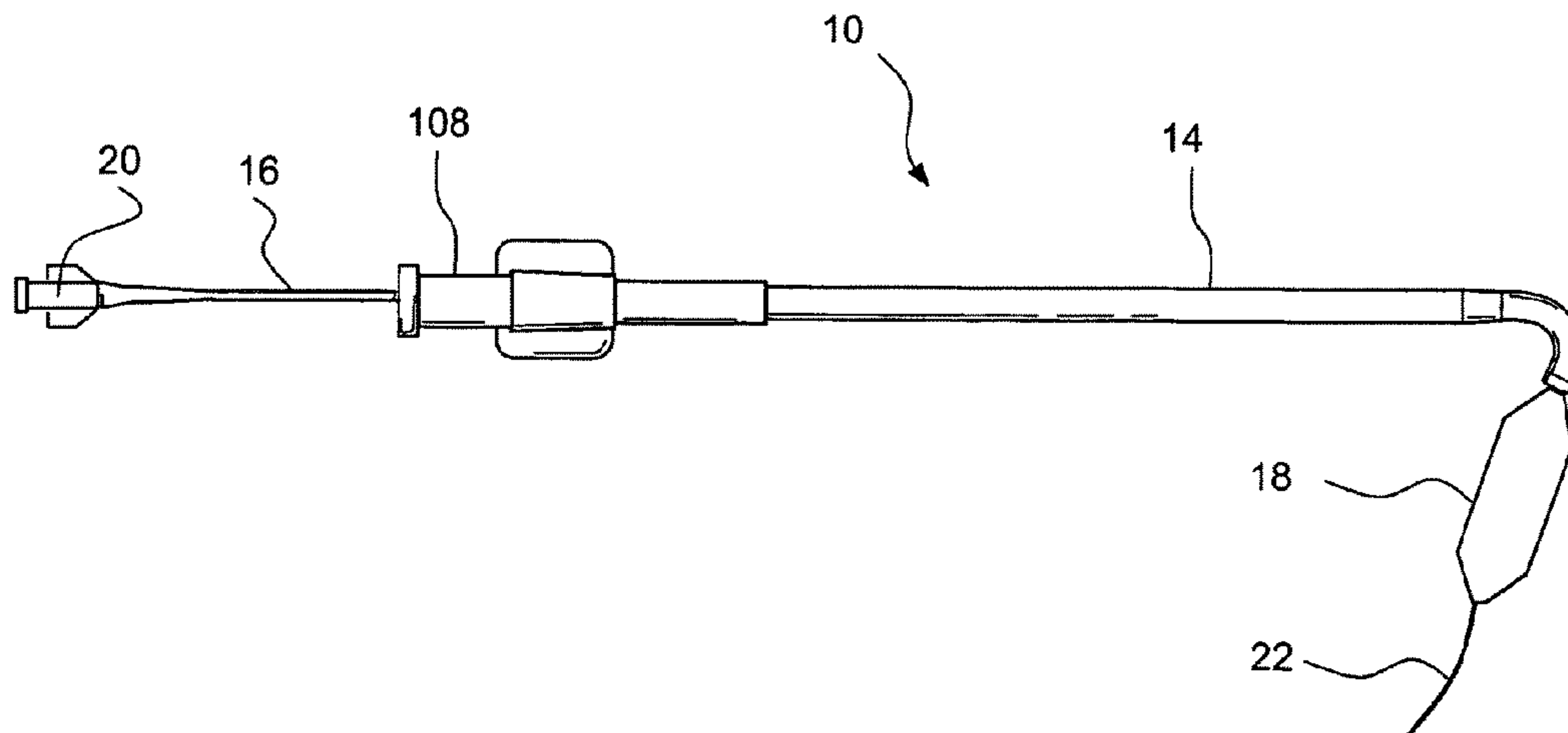
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(57) **ABSTRACT**

Balloon catheter, guide catheter and method for dilating openings in paranasal sinuses. A non-removable guide member (e.g., guidewire) extends from the distal end of the balloon catheter. The non-removable guide member initially passes through the opening of the paranasal sinus and is followed by the catheter body on which the balloon is mounted. The balloon is then inflated causing dilation of the opening of the paranasal sinus. In some embodiments, the non-removable guide member may be shapeable so that the operator may place the non-removable guide member in a desired shape prior to insertion of the balloon catheter. In some embodiments, the length of the non-removable guide member may be adjustable such that the operator may adjust the length of the non-removable guide member prior to insertion of the balloon catheter.

20 Claims, 15 Drawing Sheets



Related U.S. Application Data

continuation of application No. 11/438,090, filed on May 18, 2006, now Pat. No. 8,951,225, which is a continuation-in-part of application No. 11/193,020, filed on Jul. 29, 2005, now abandoned, which is a continuation-in-part of application No. 11/150,847, filed on Jun. 10, 2005, now Pat. No. 7,803,150.

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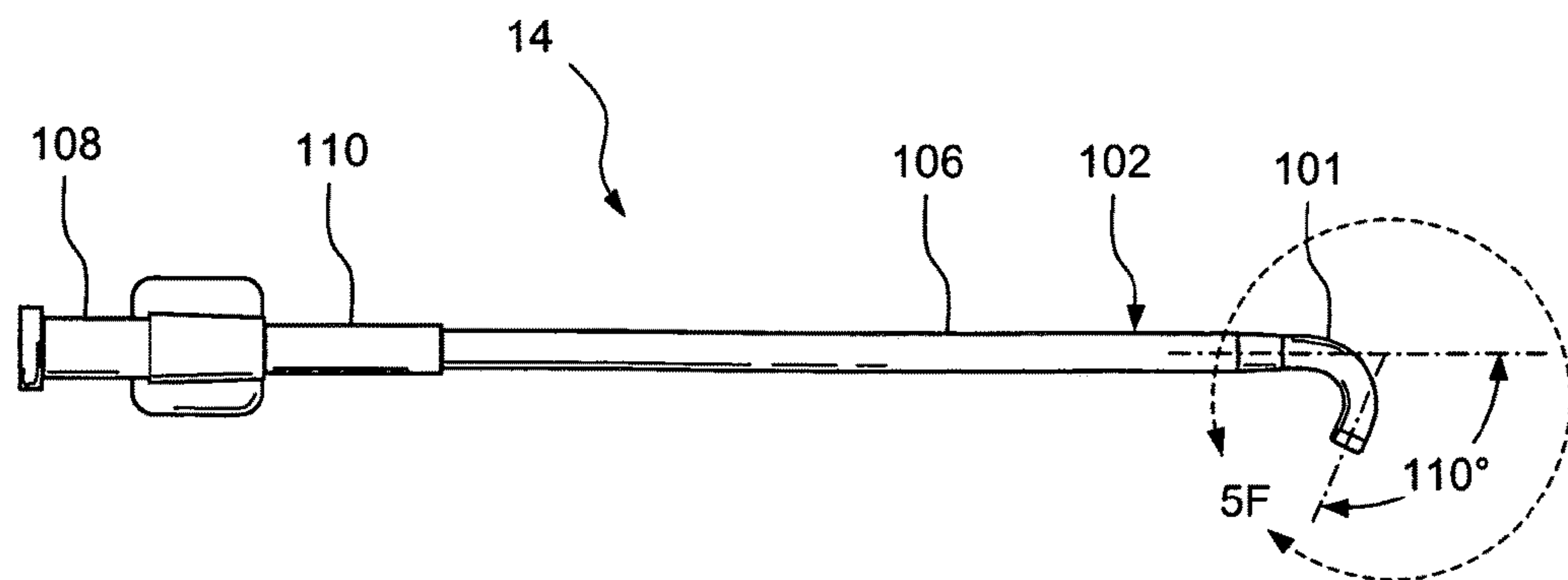
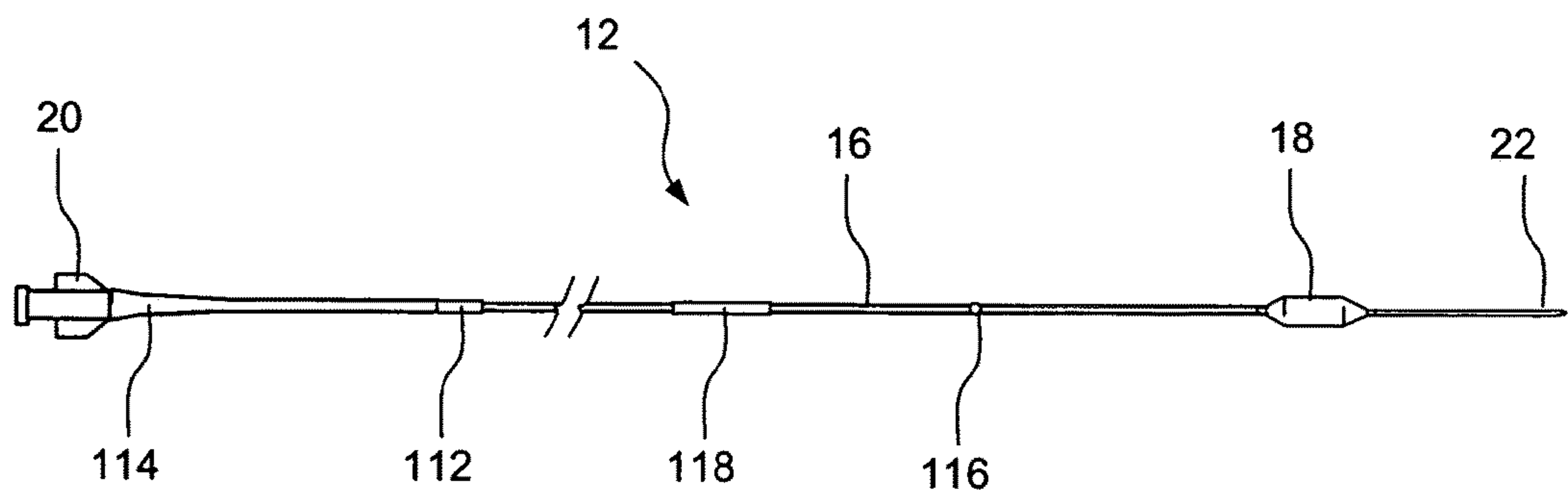
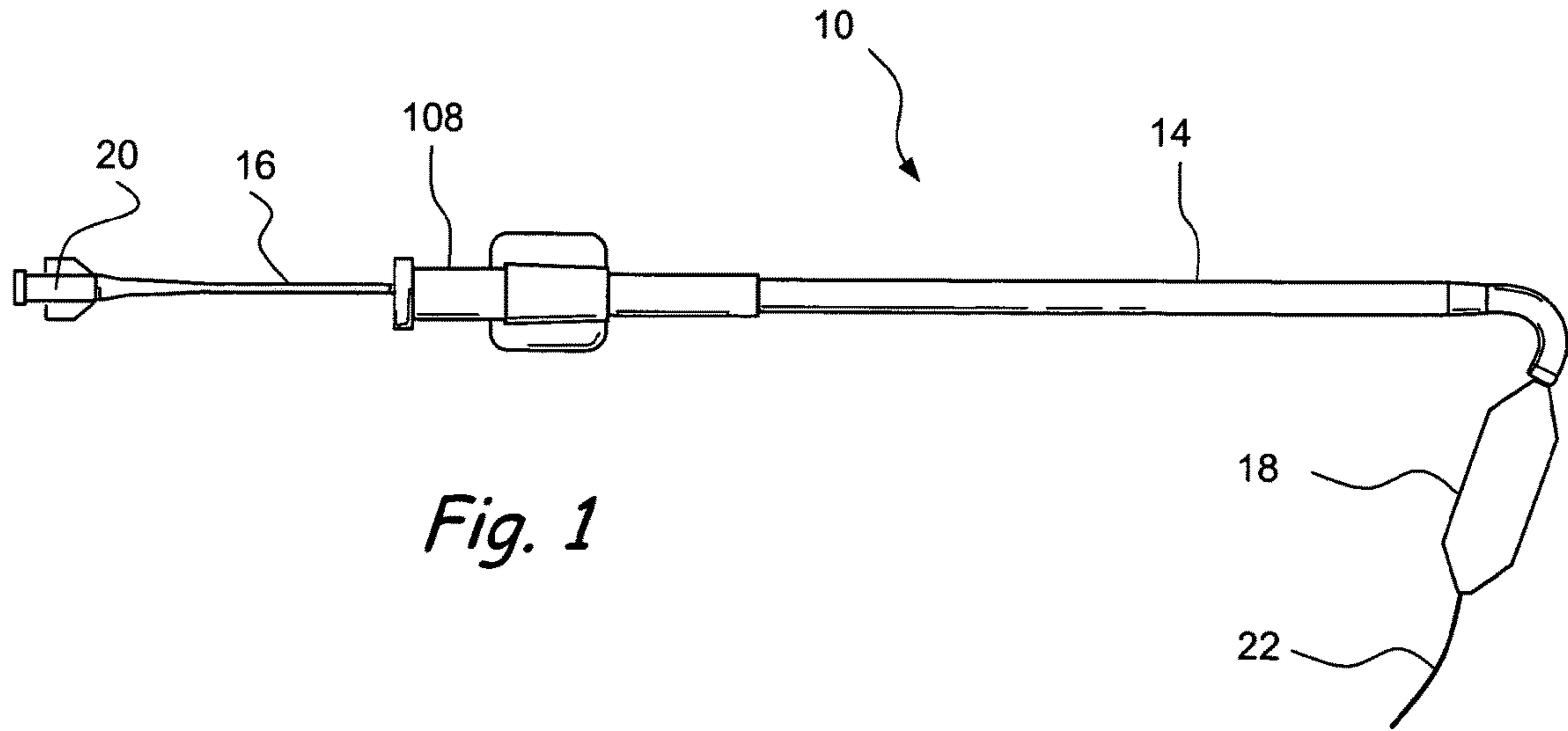
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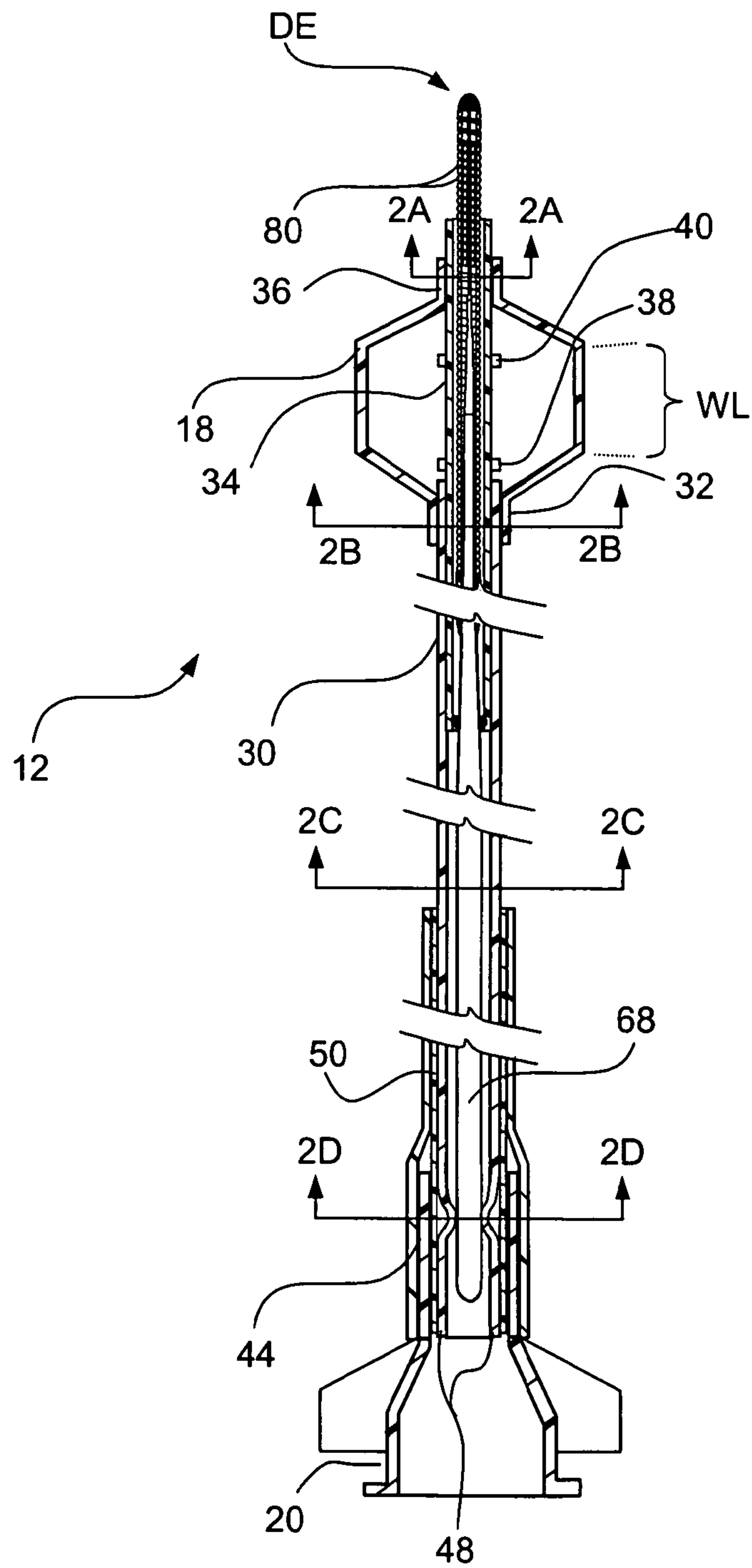


Fig. 2

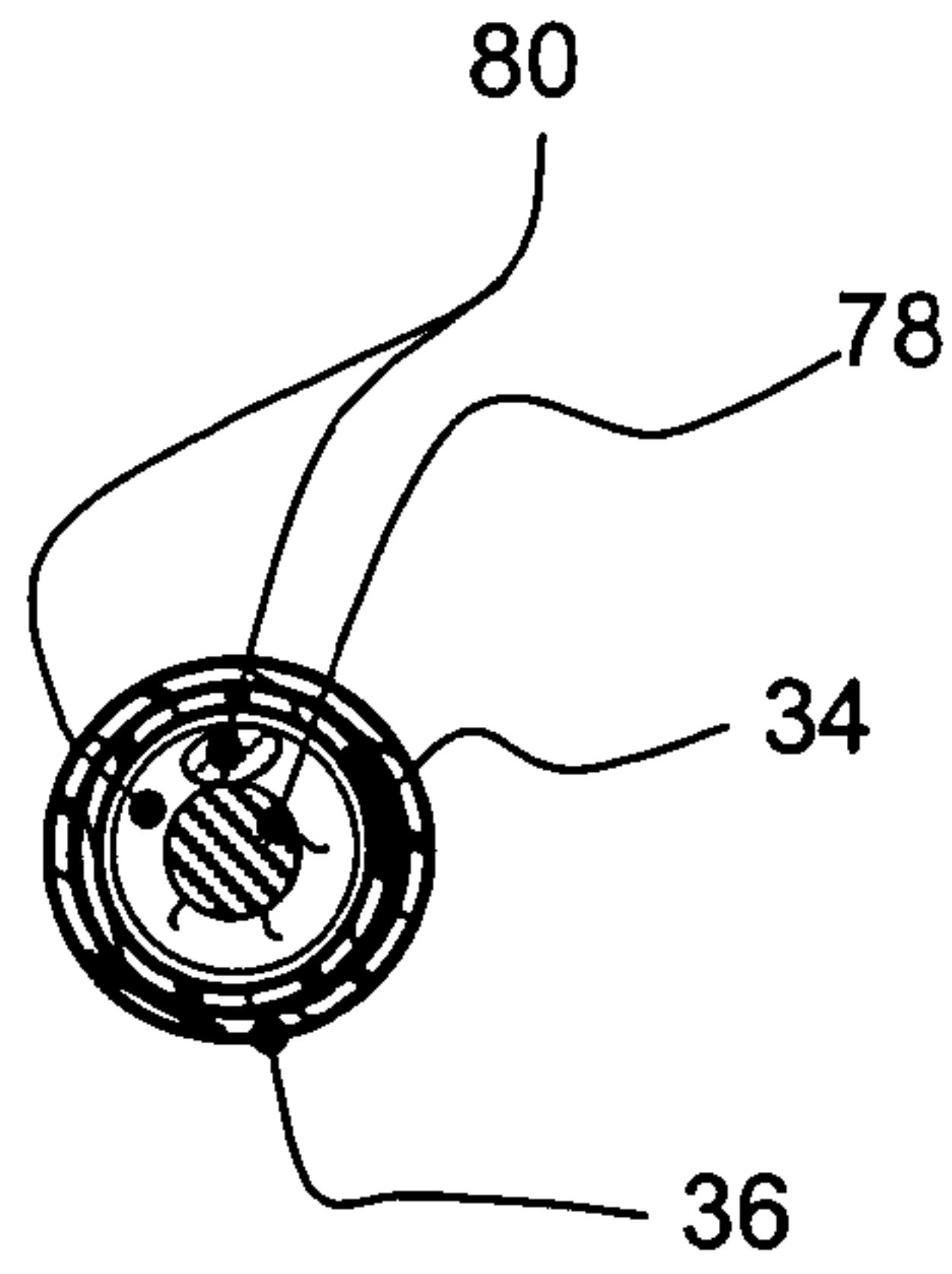


Fig. 2 A

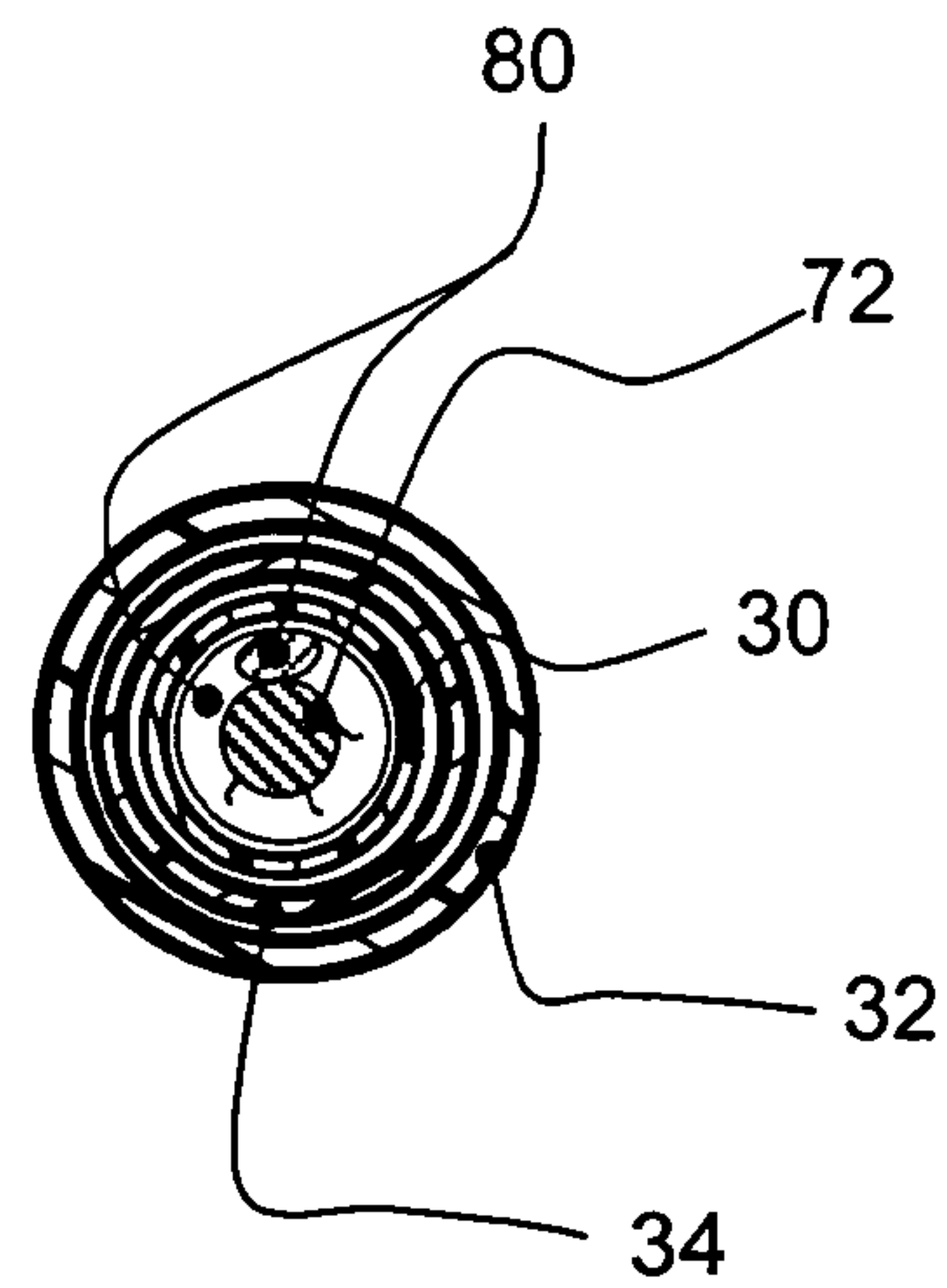


Fig. 2 B

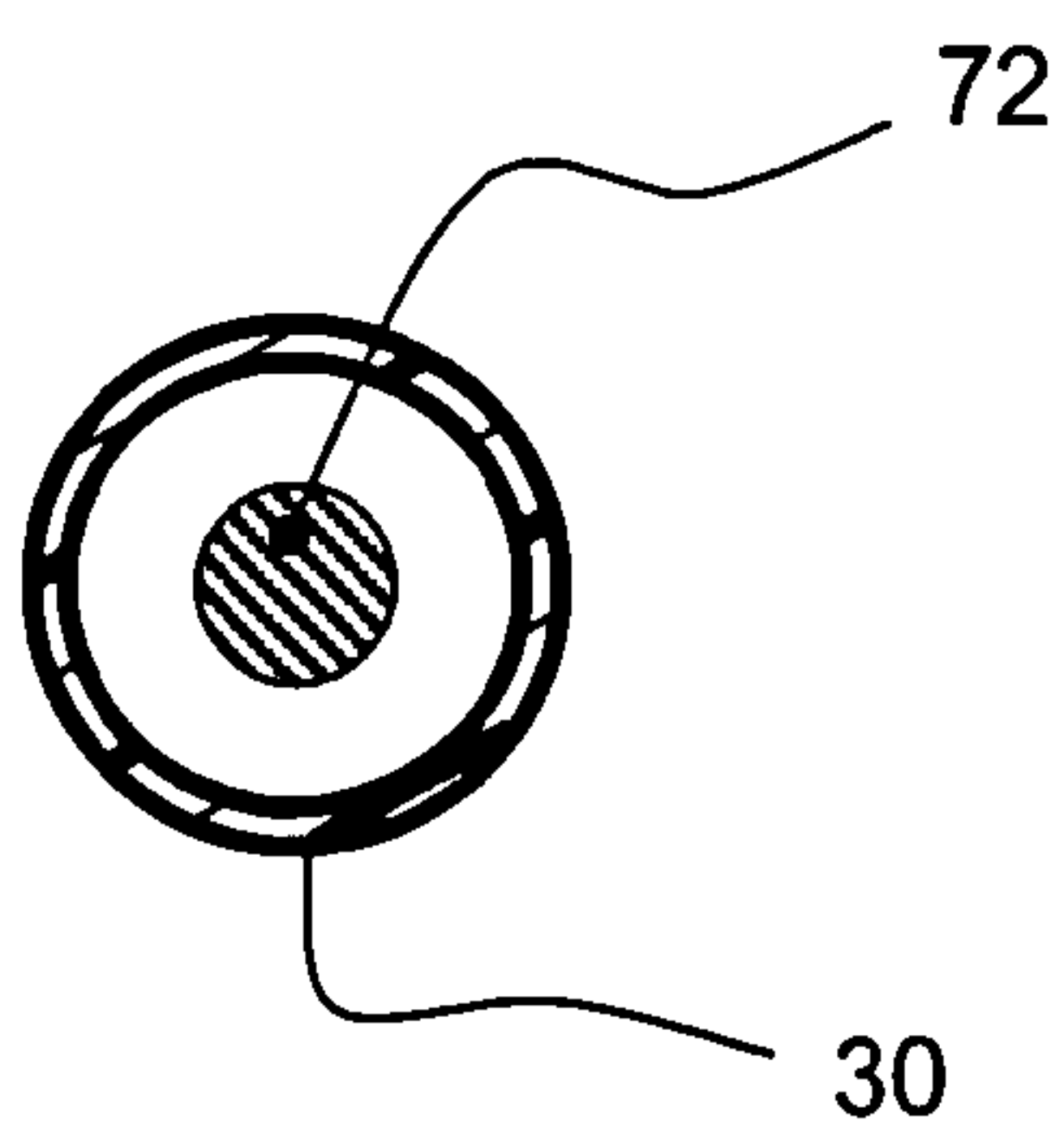


Fig. 2 C

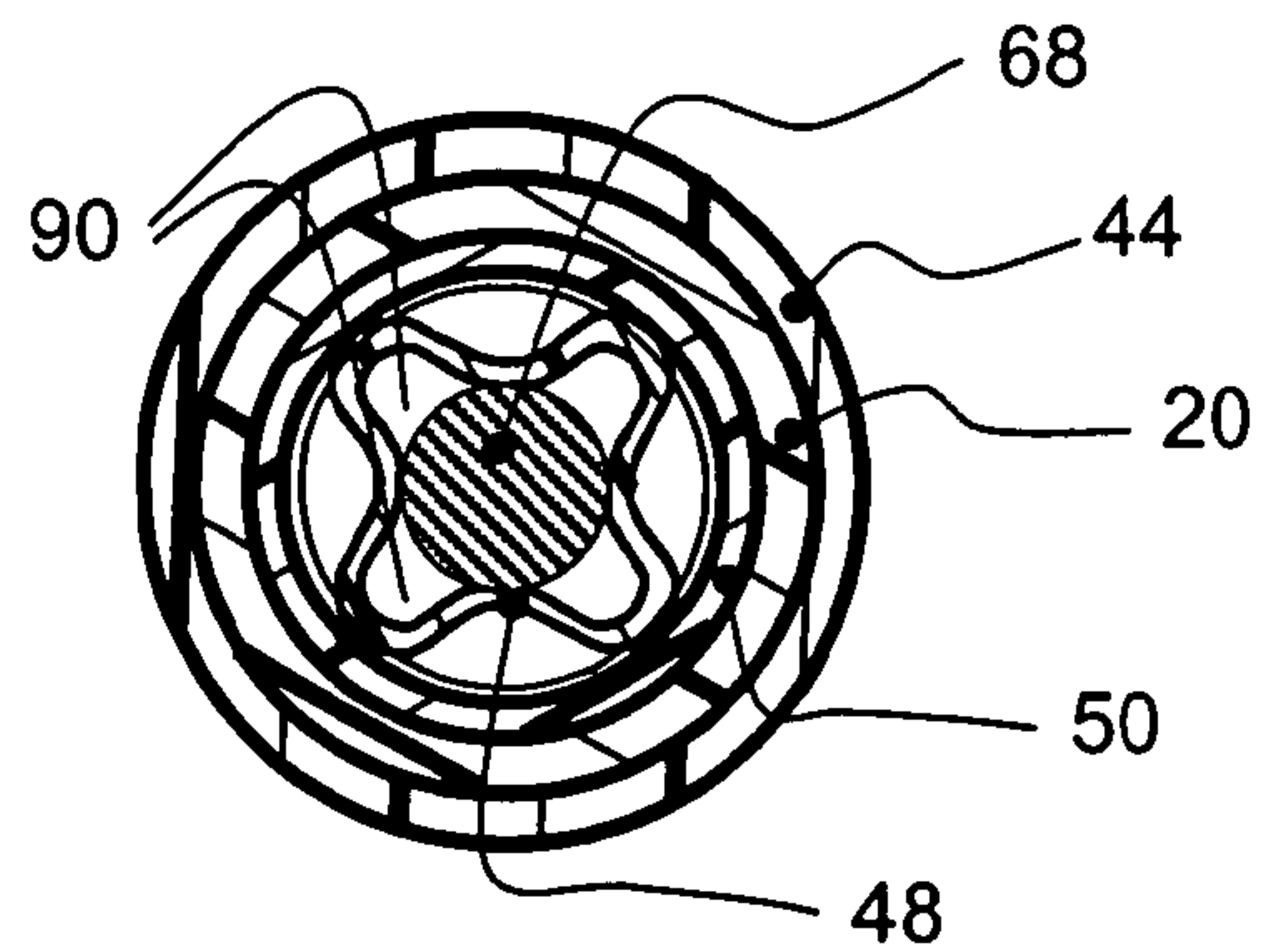


Fig. 2 D

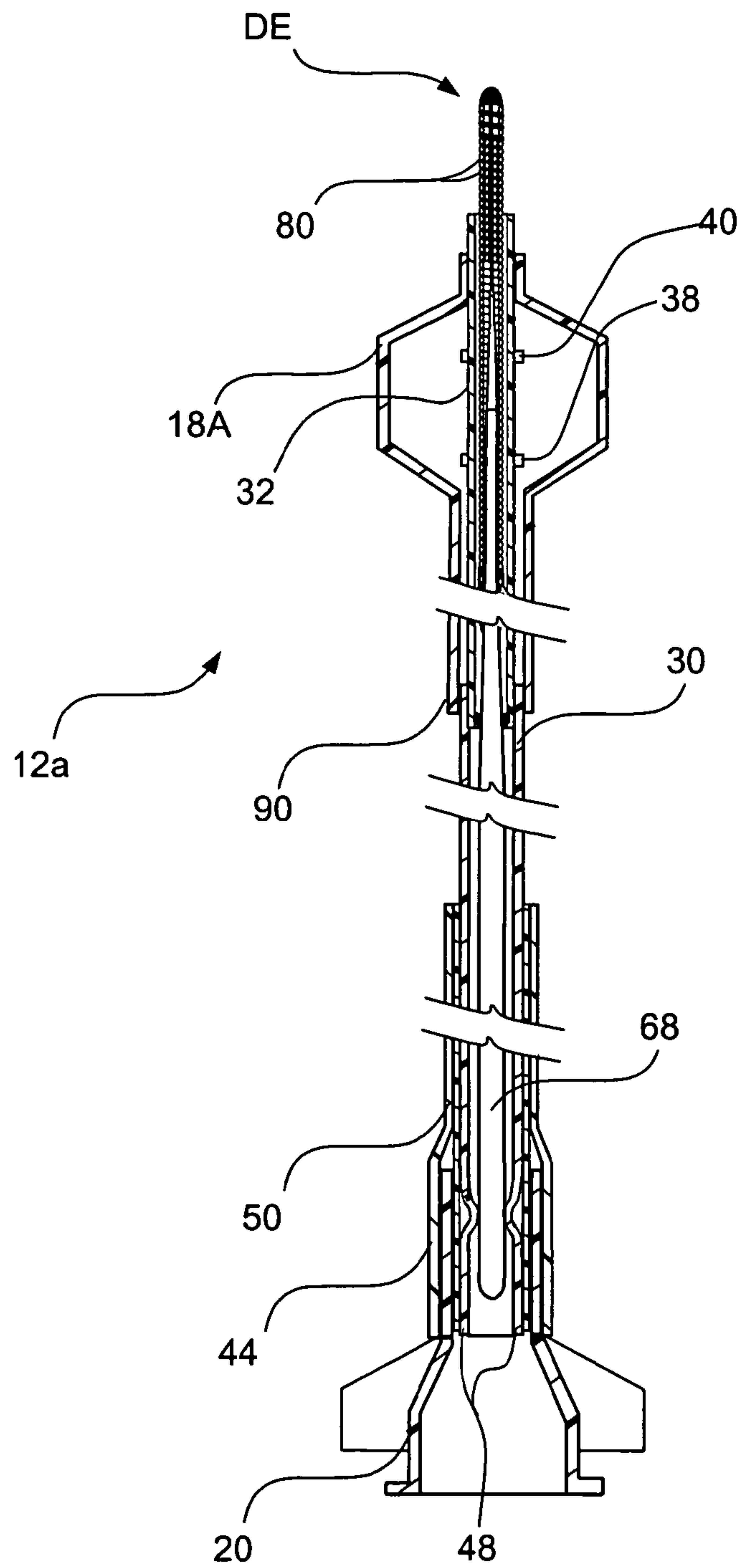


Fig. 2 E

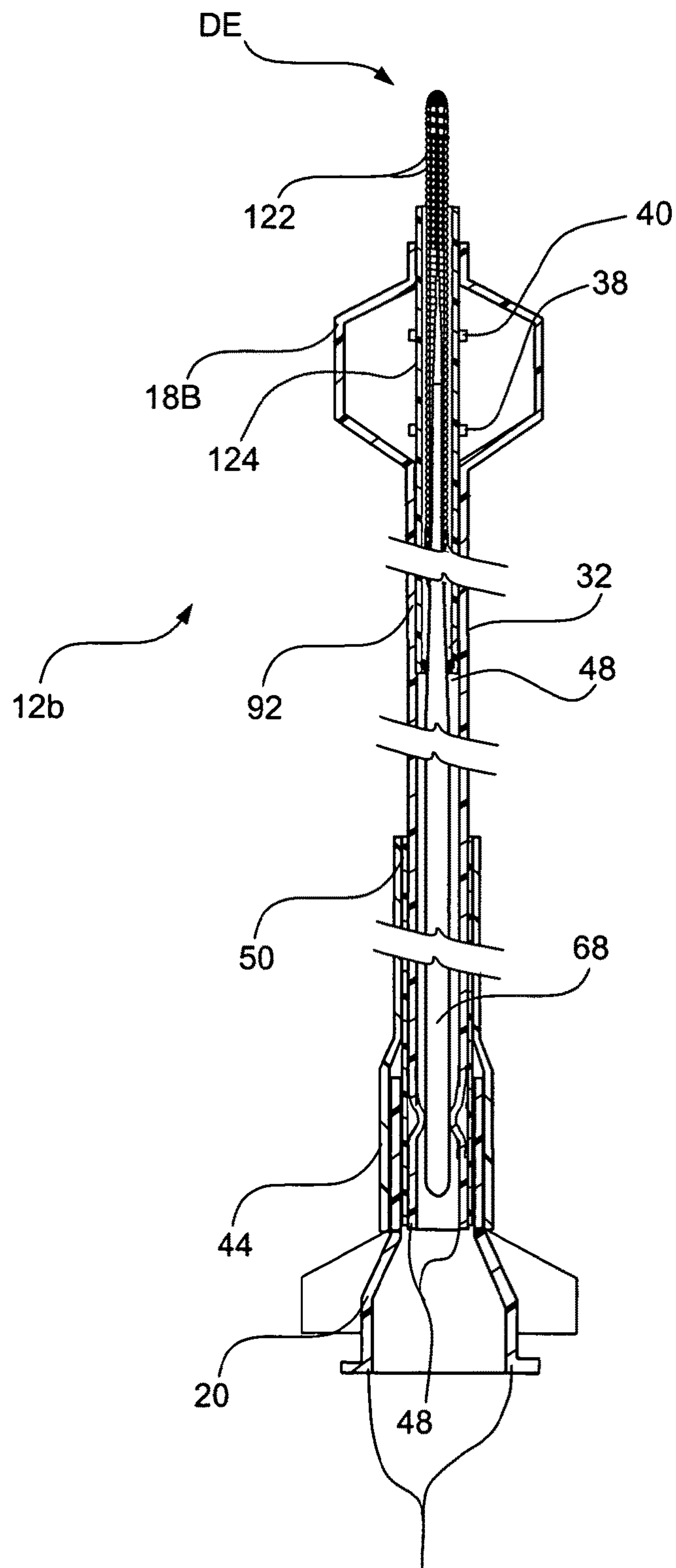
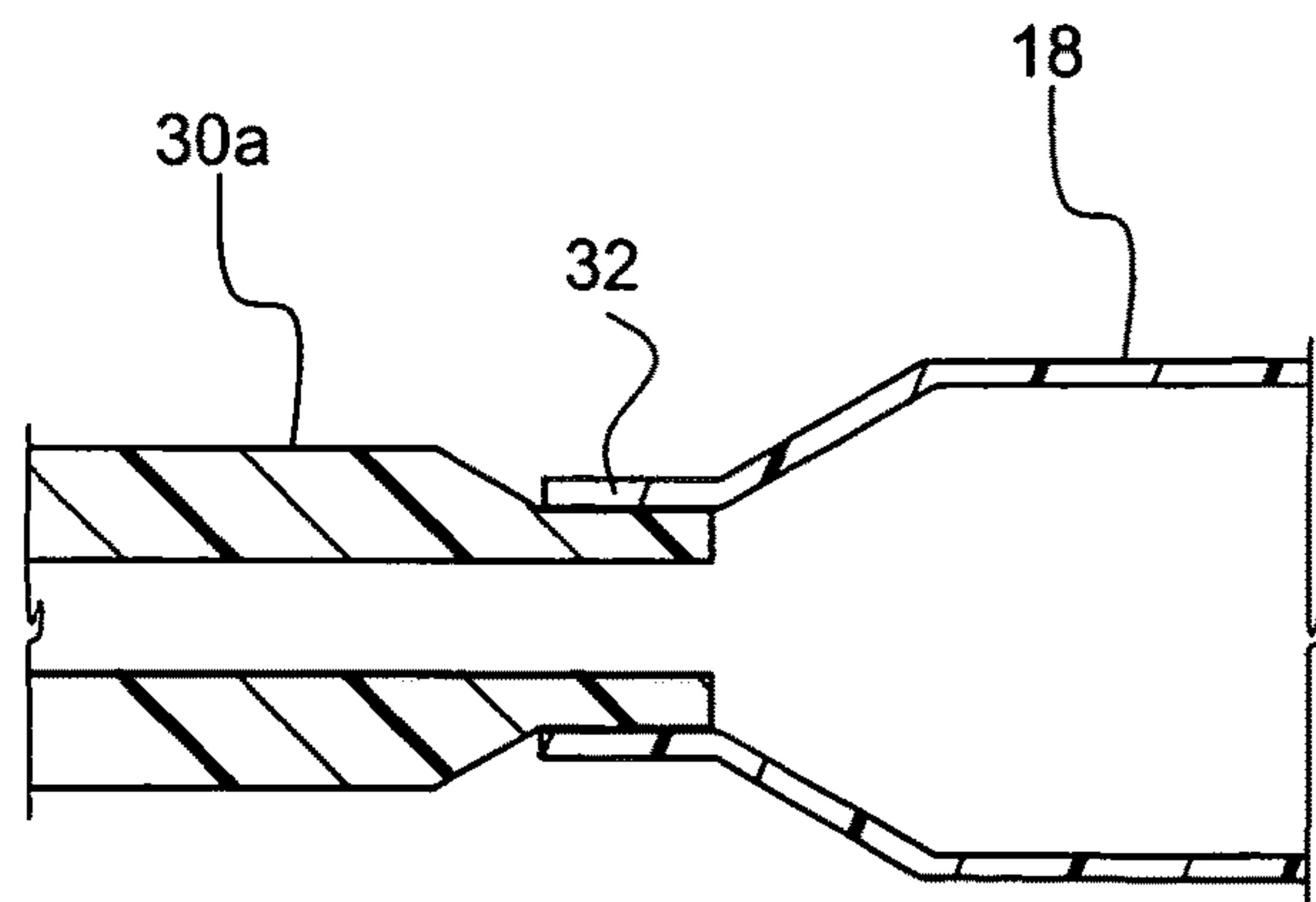
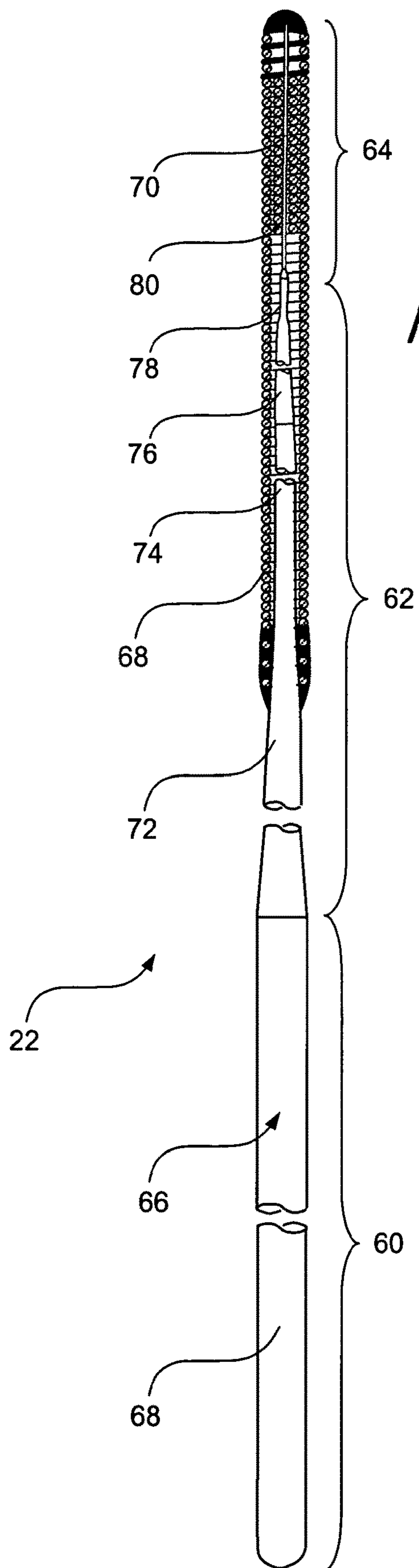
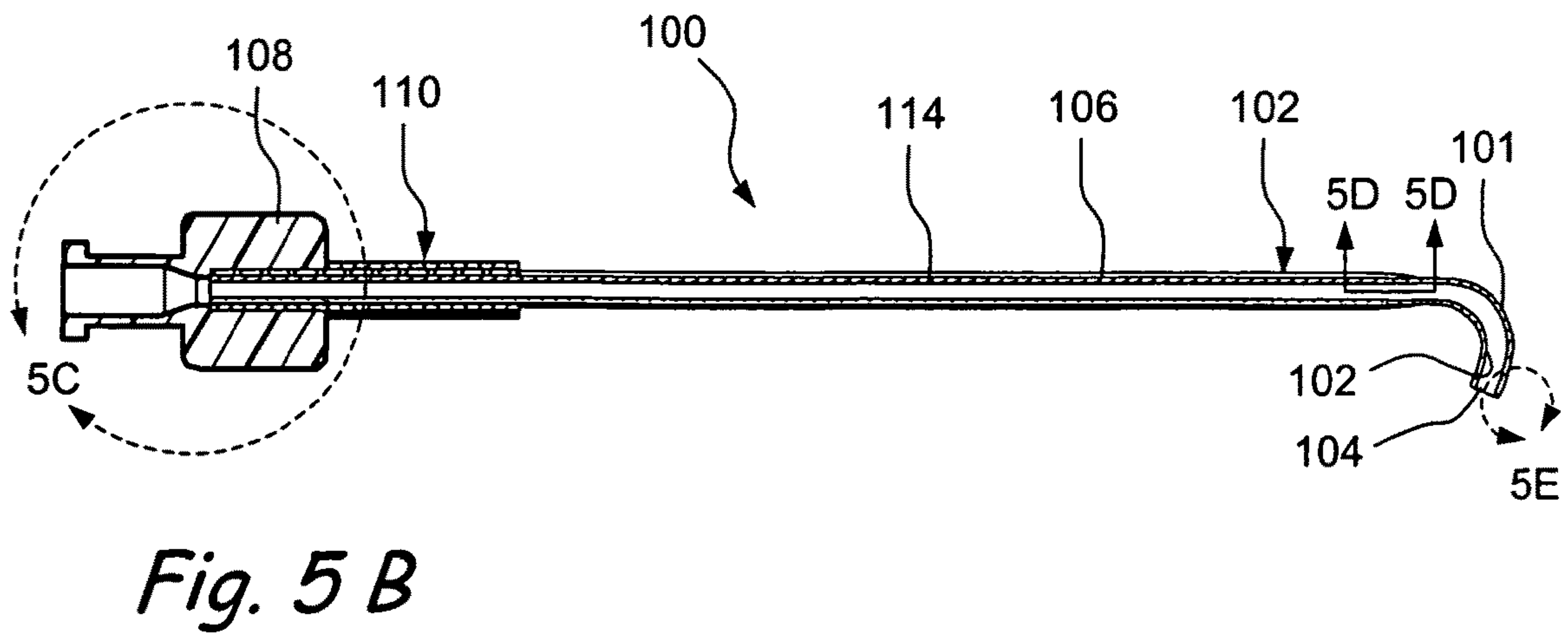
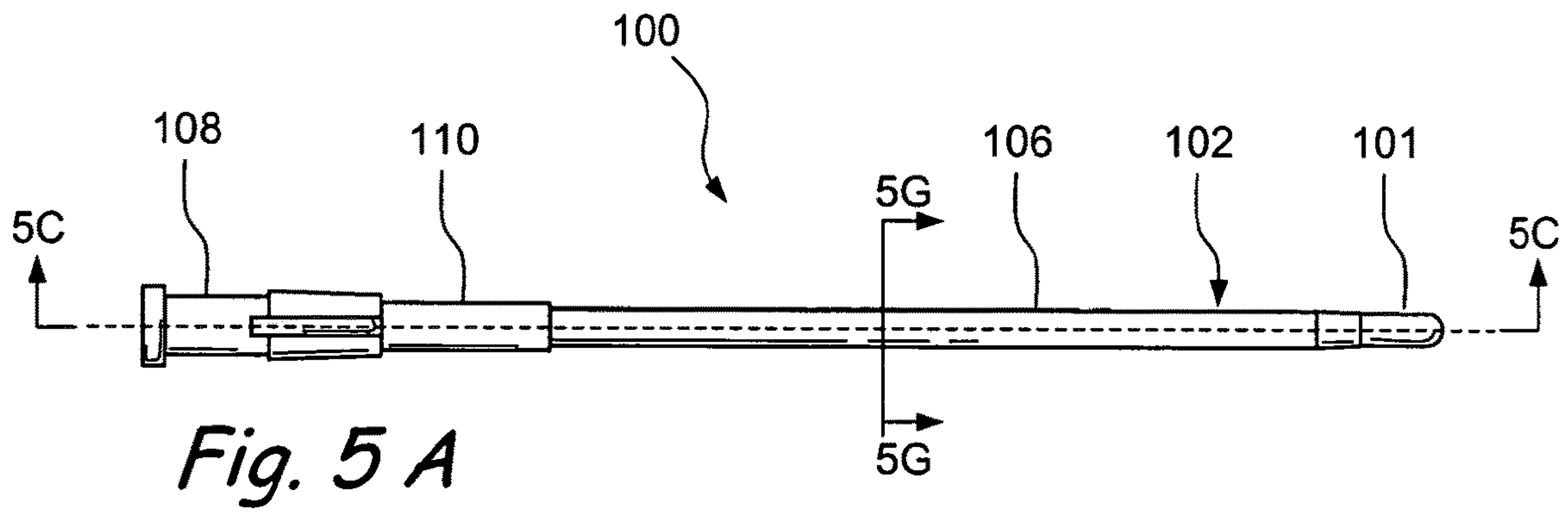


Fig. 2 F





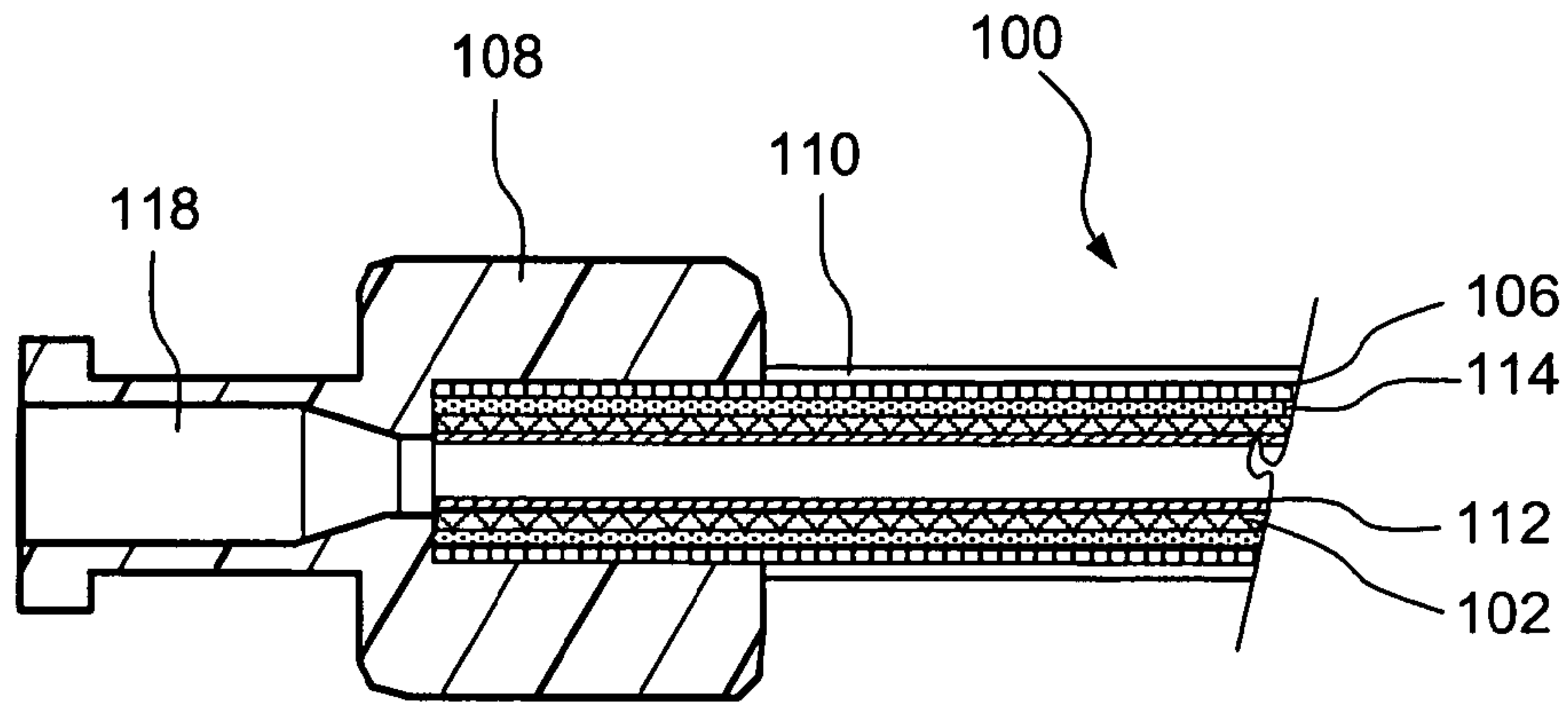


Fig. 5 C

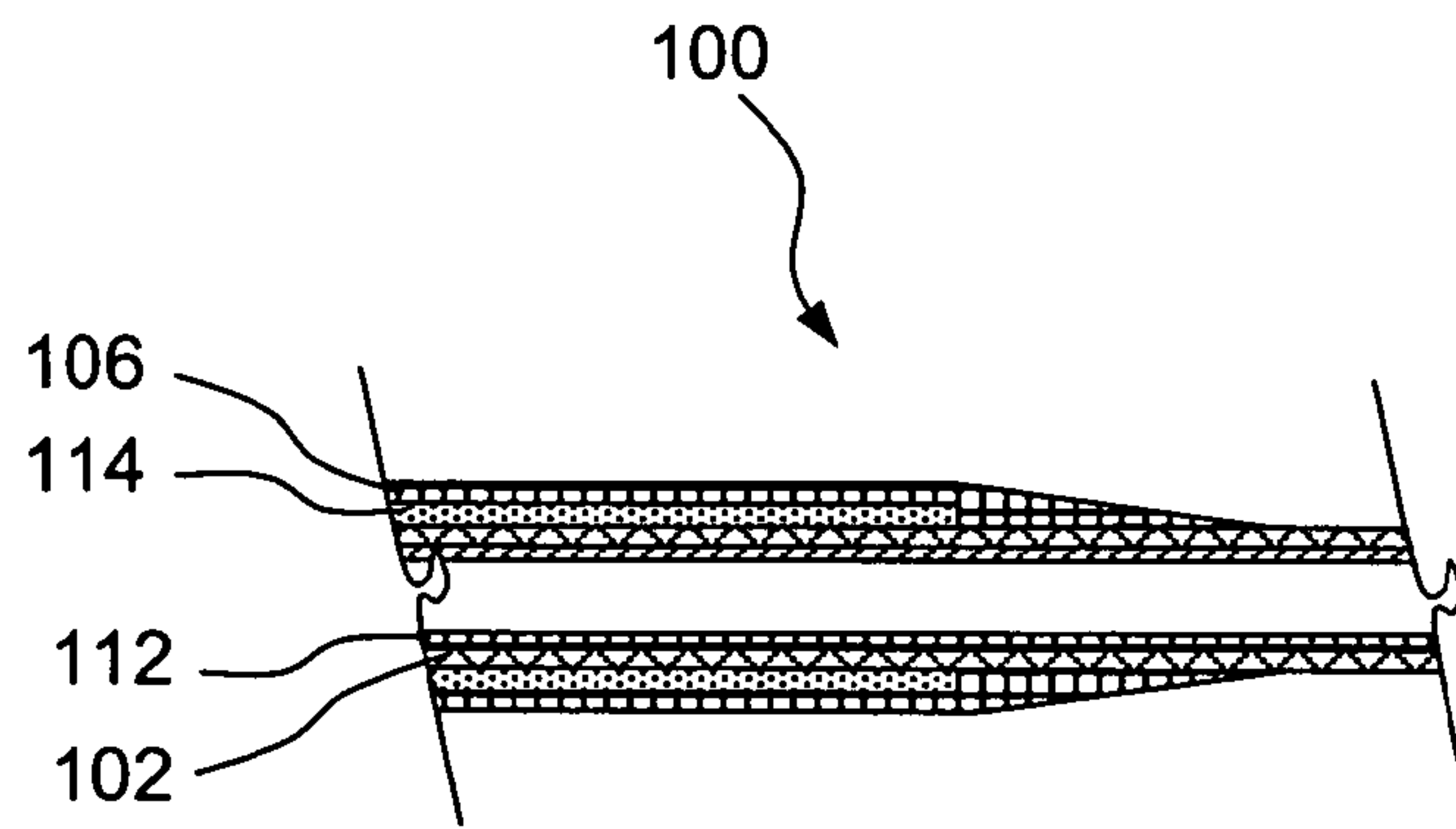


Fig. 5 D

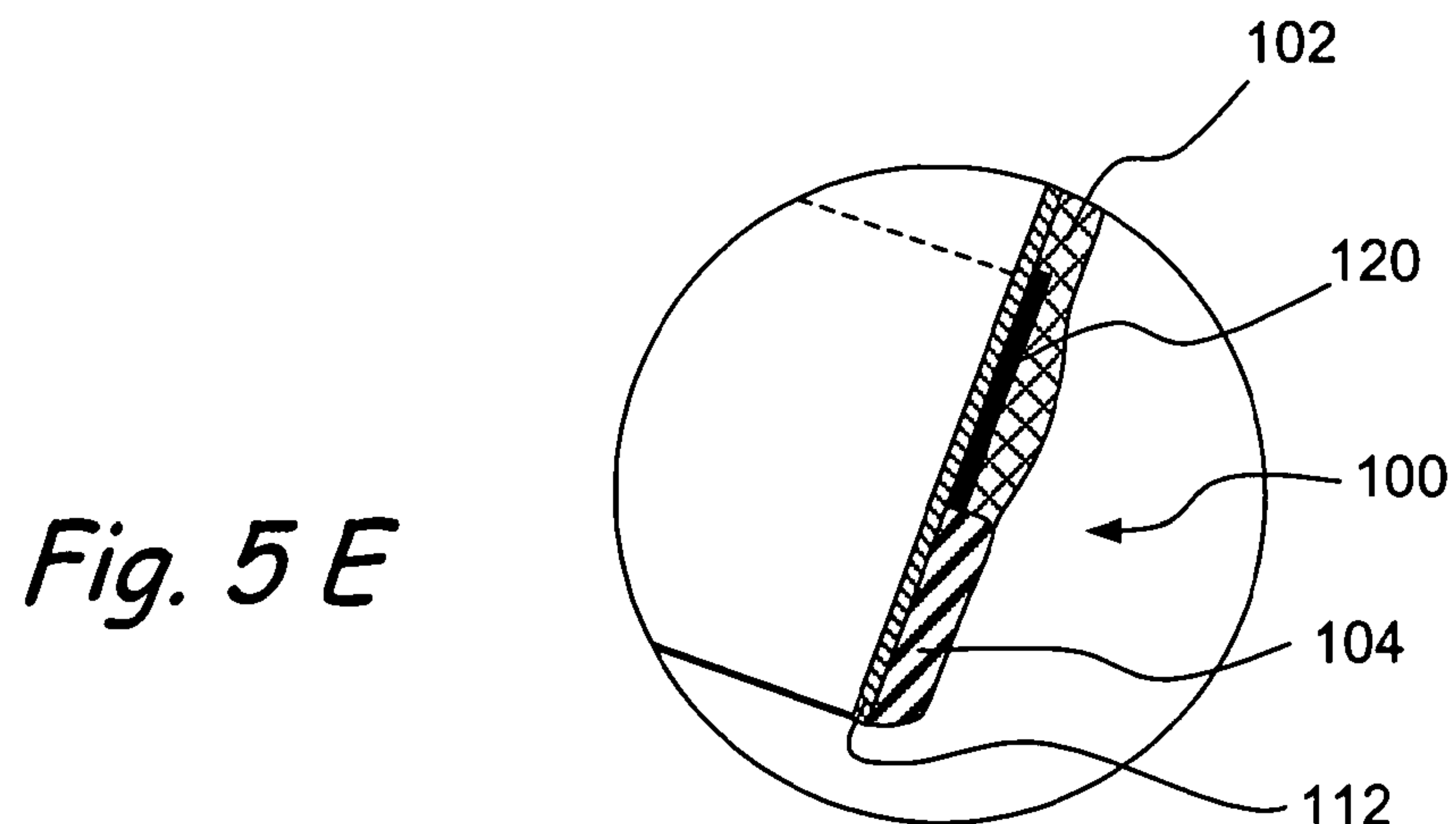


Fig. 5 E

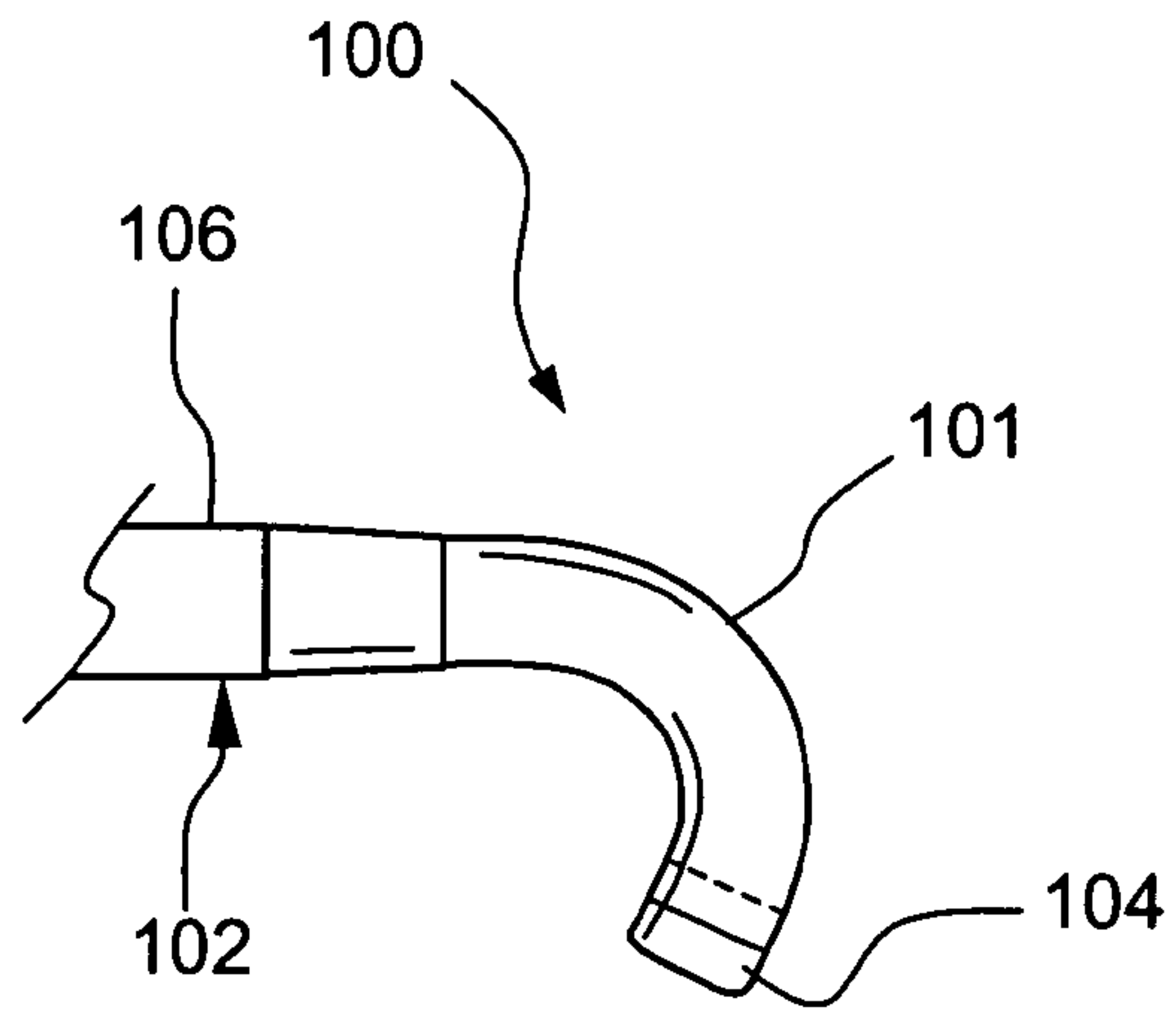


Fig. 5 F

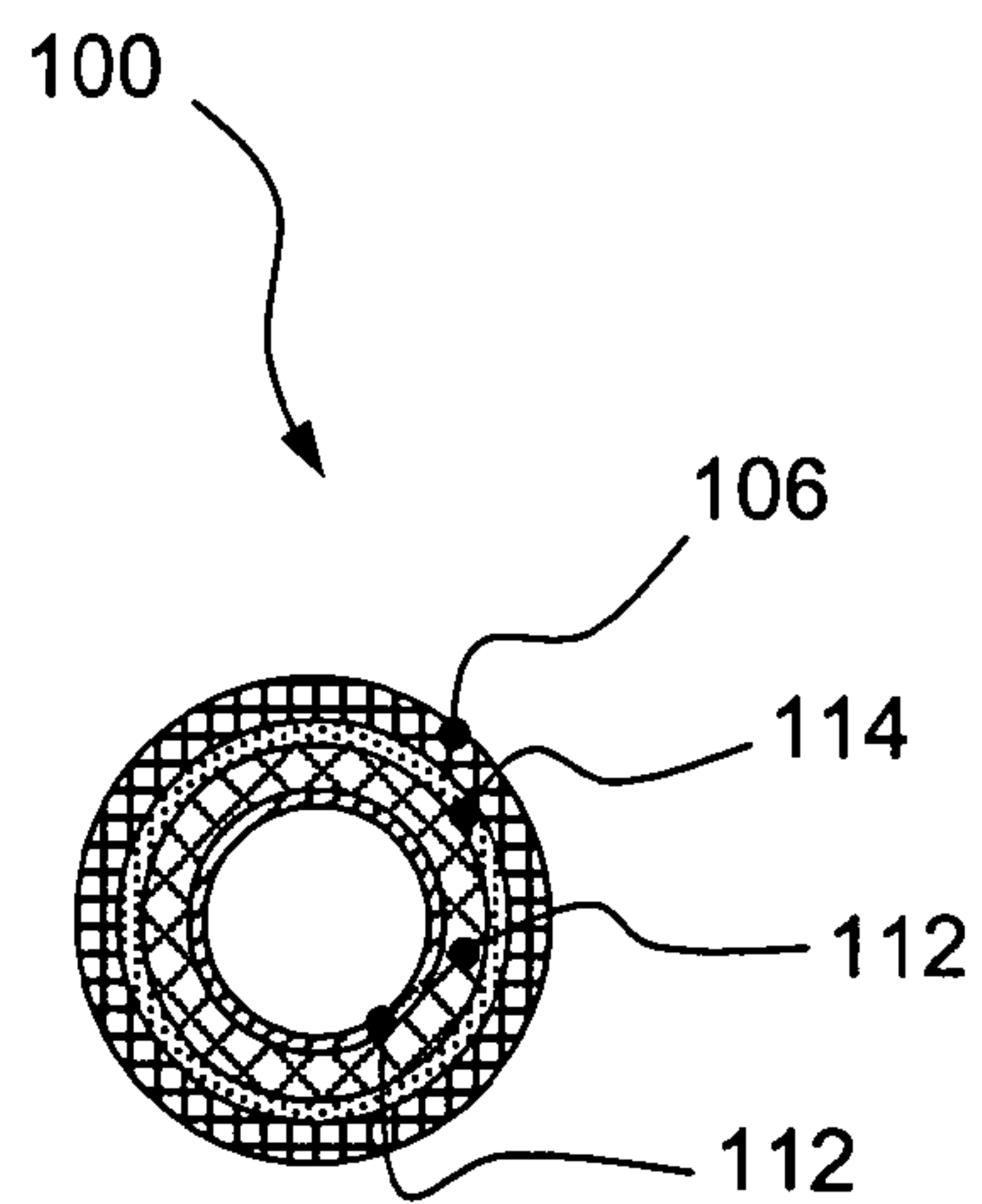


Fig. 5 G

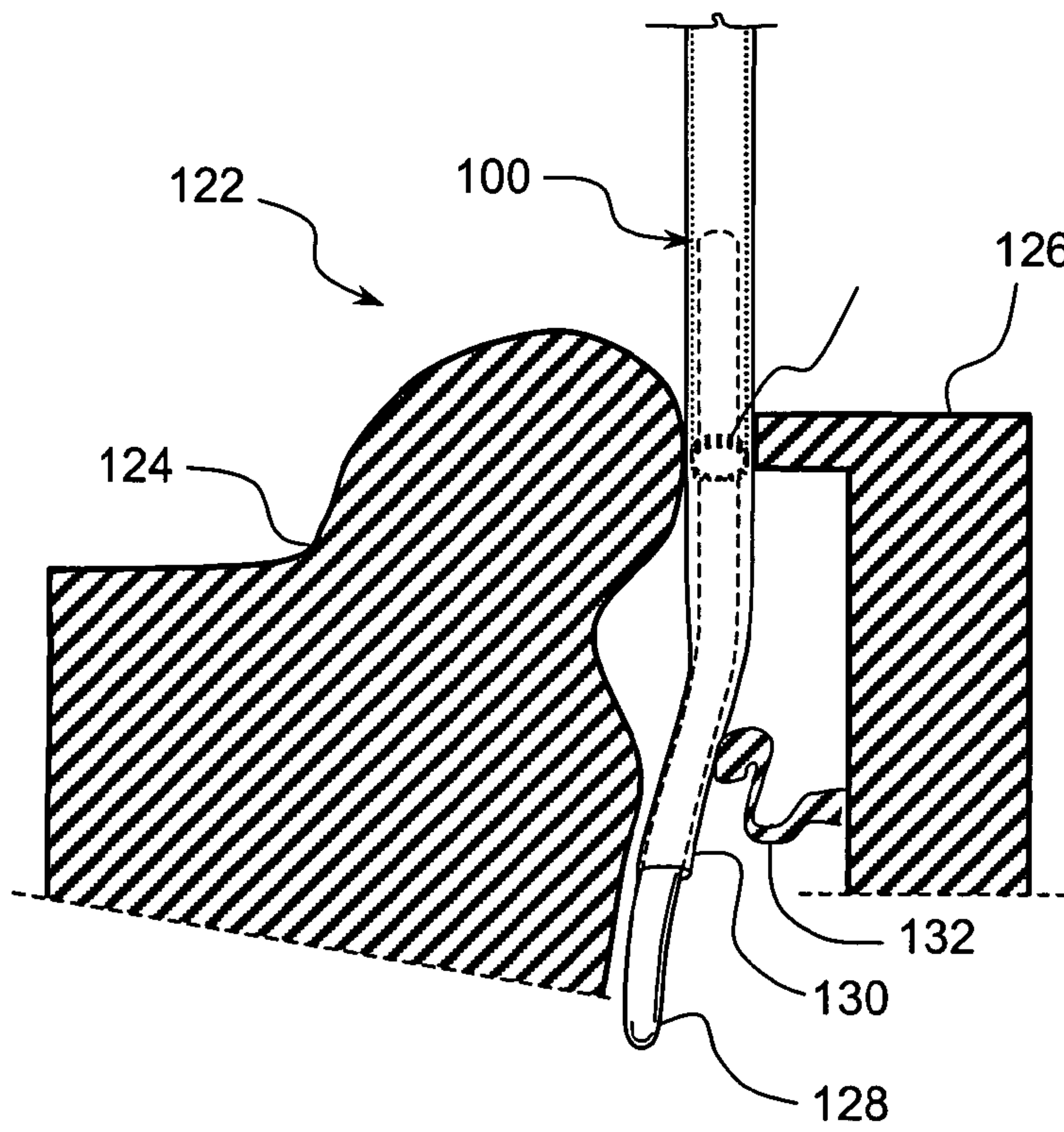


Fig. 6 A

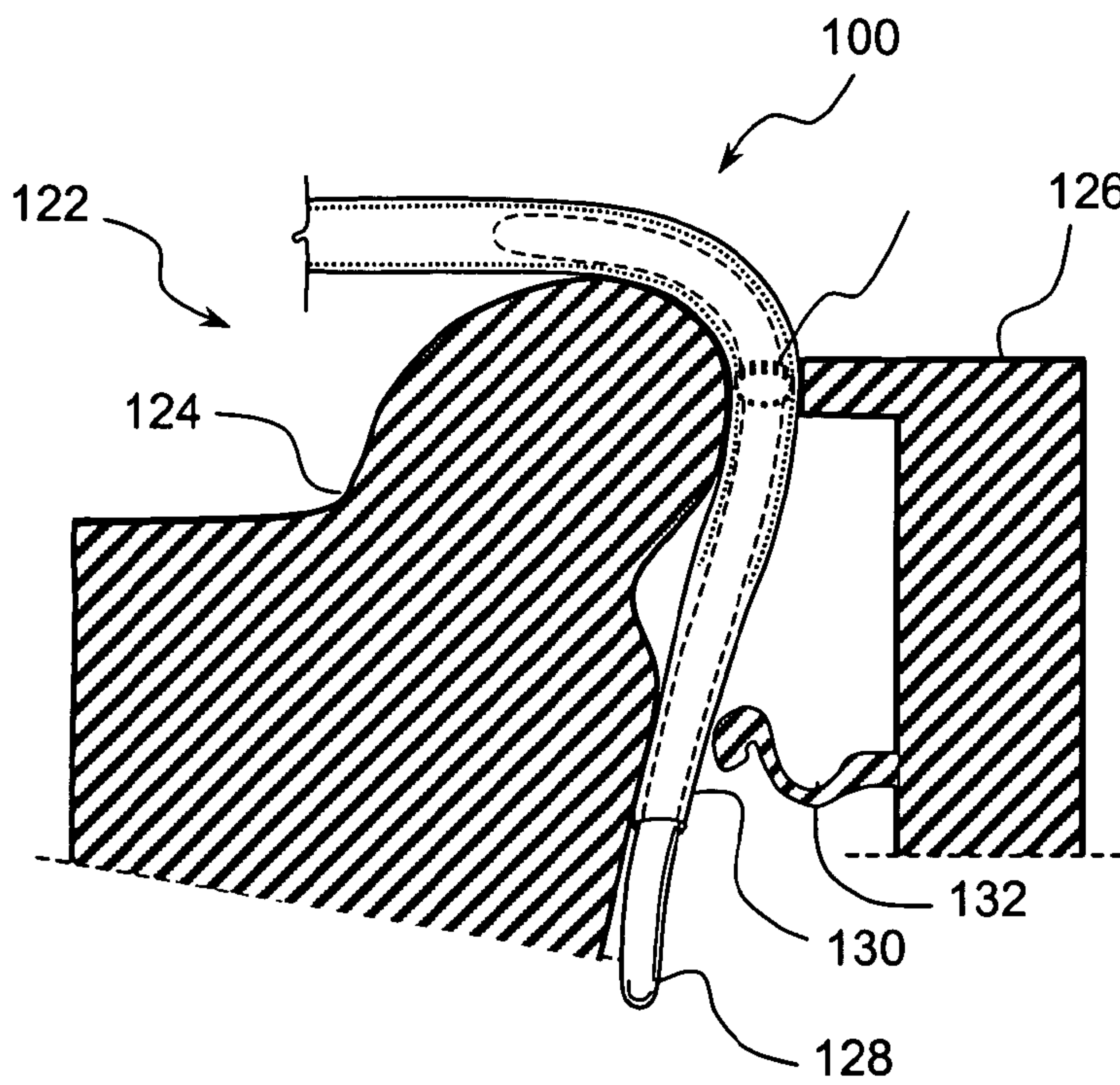


Fig. 6 B

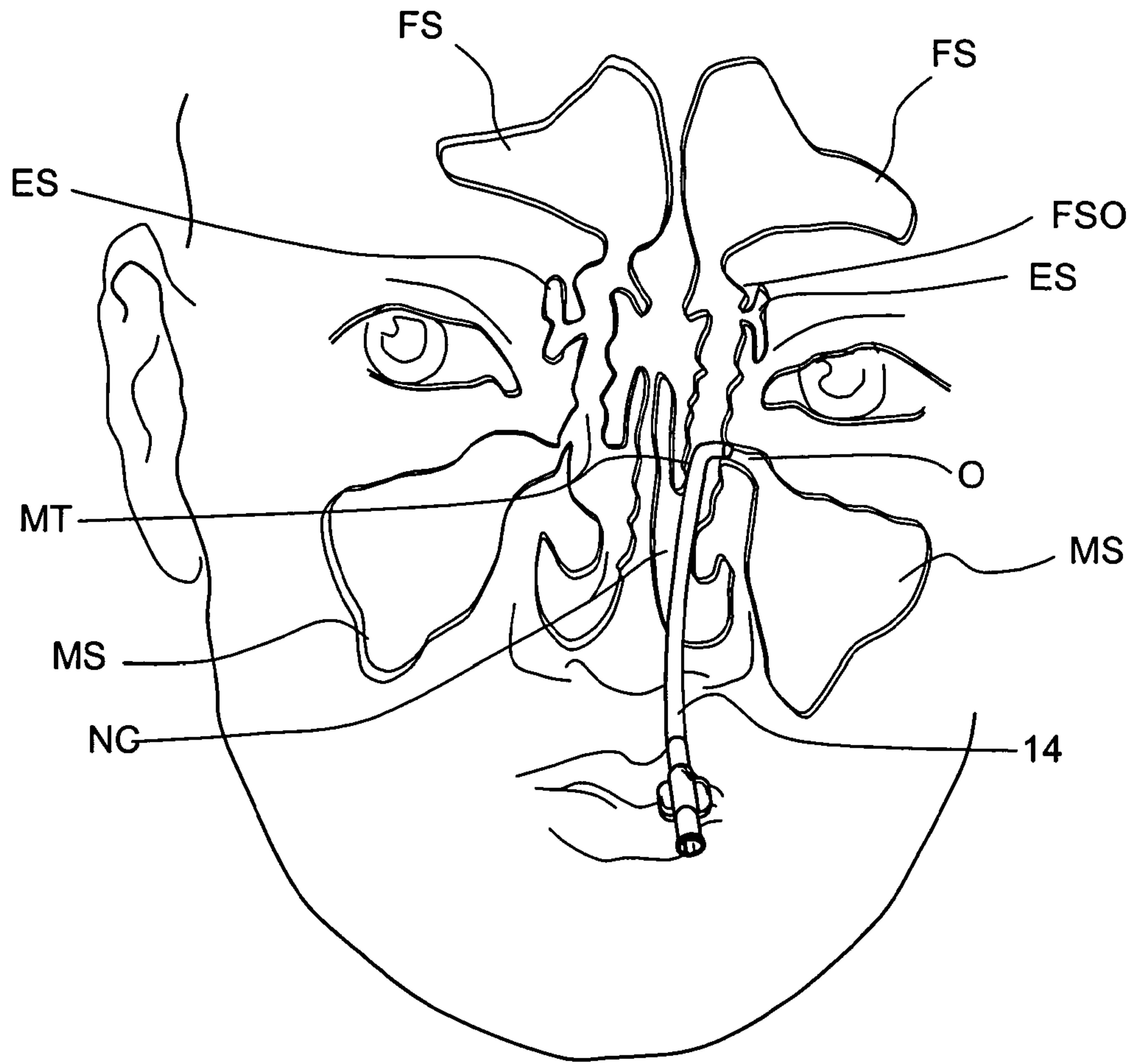
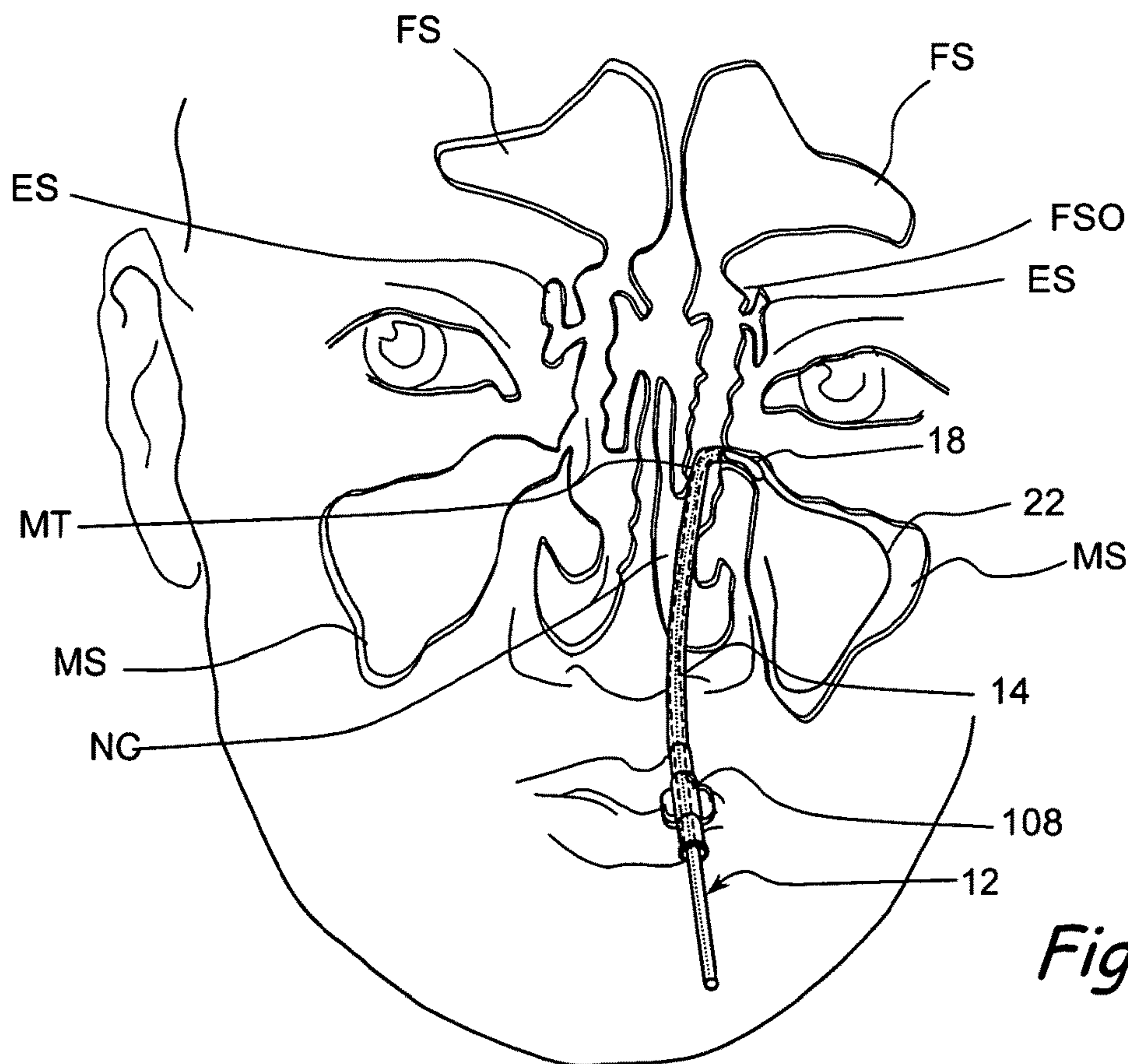
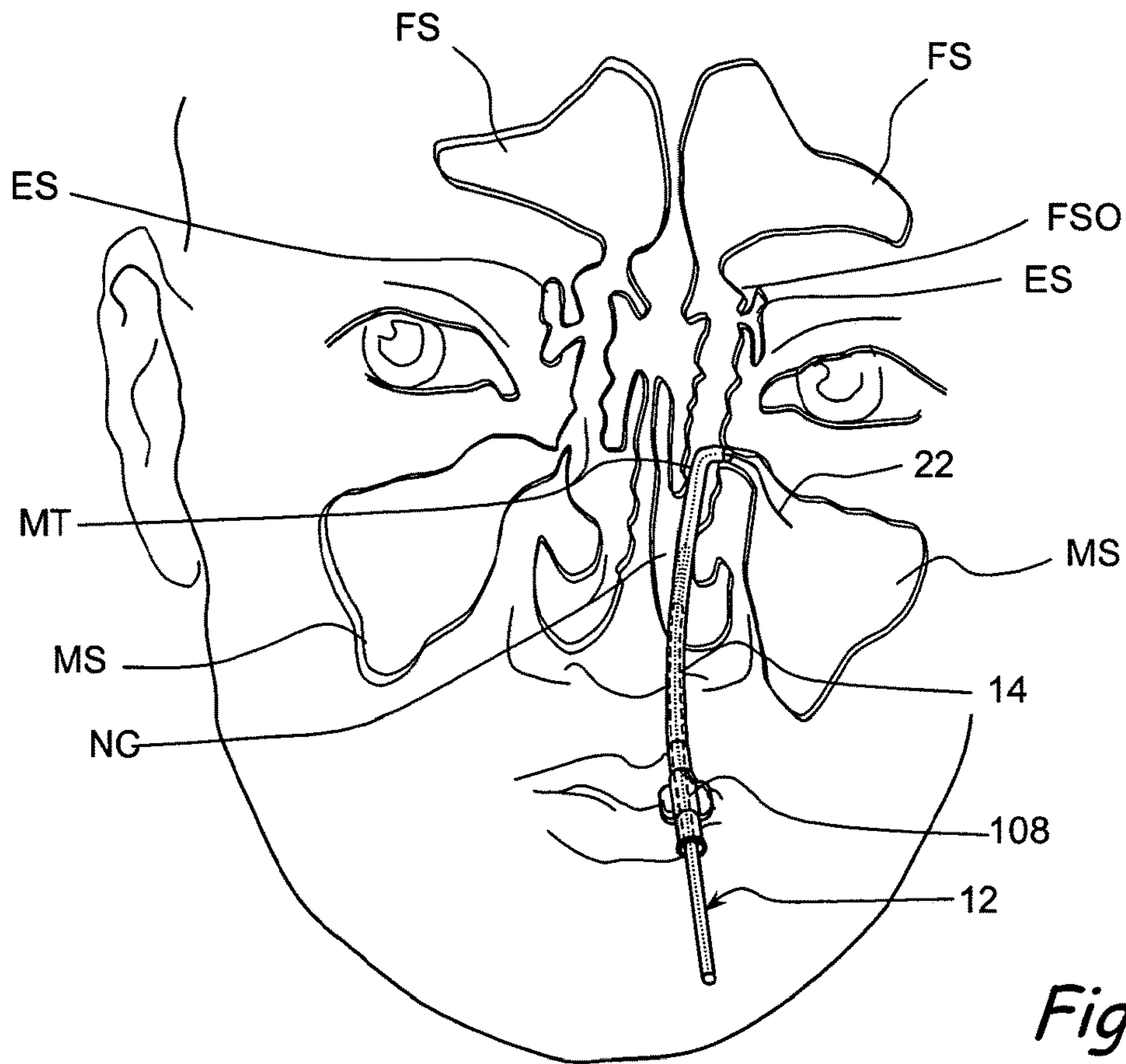


Fig. 7 A



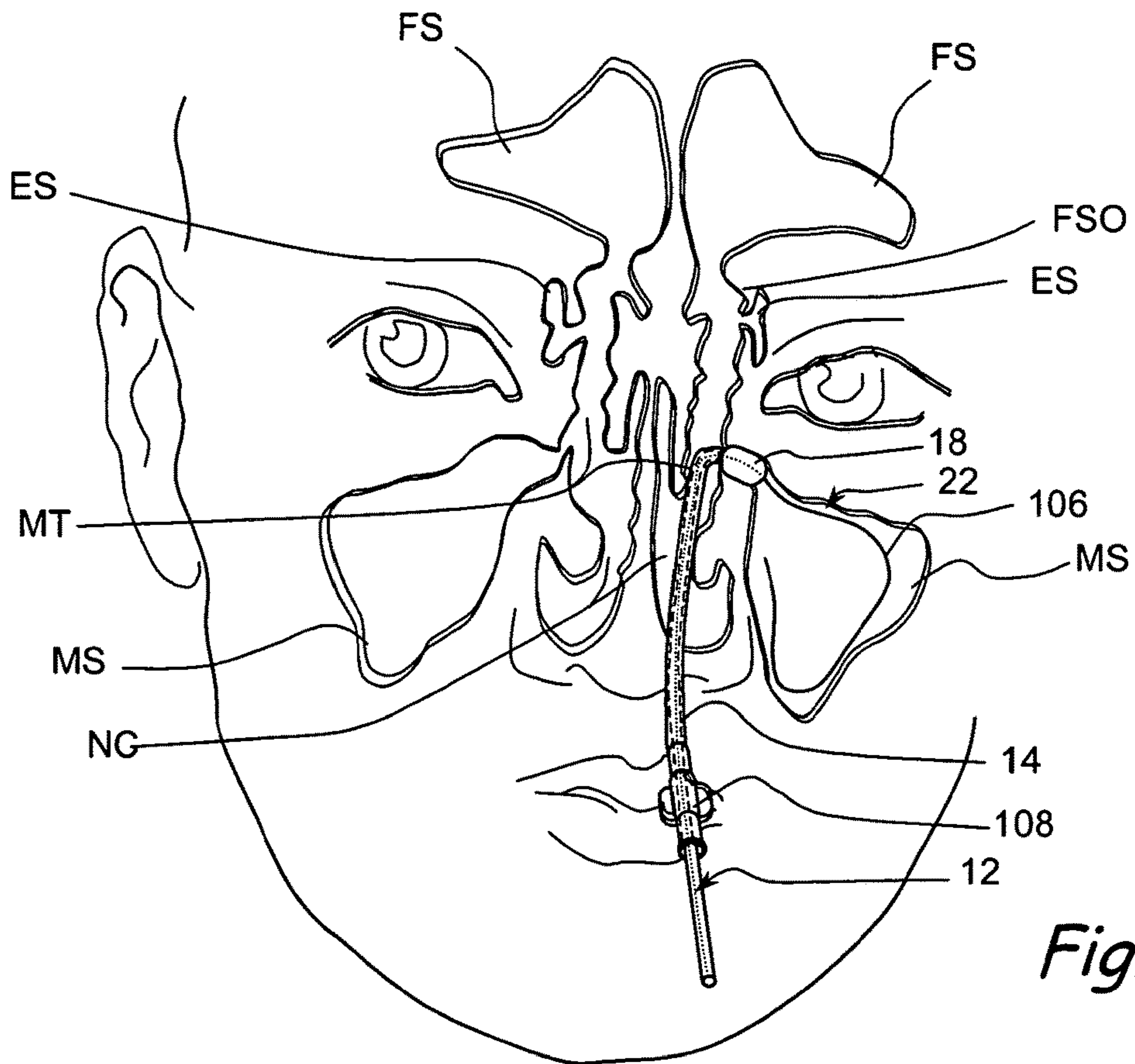


Fig. 7 D

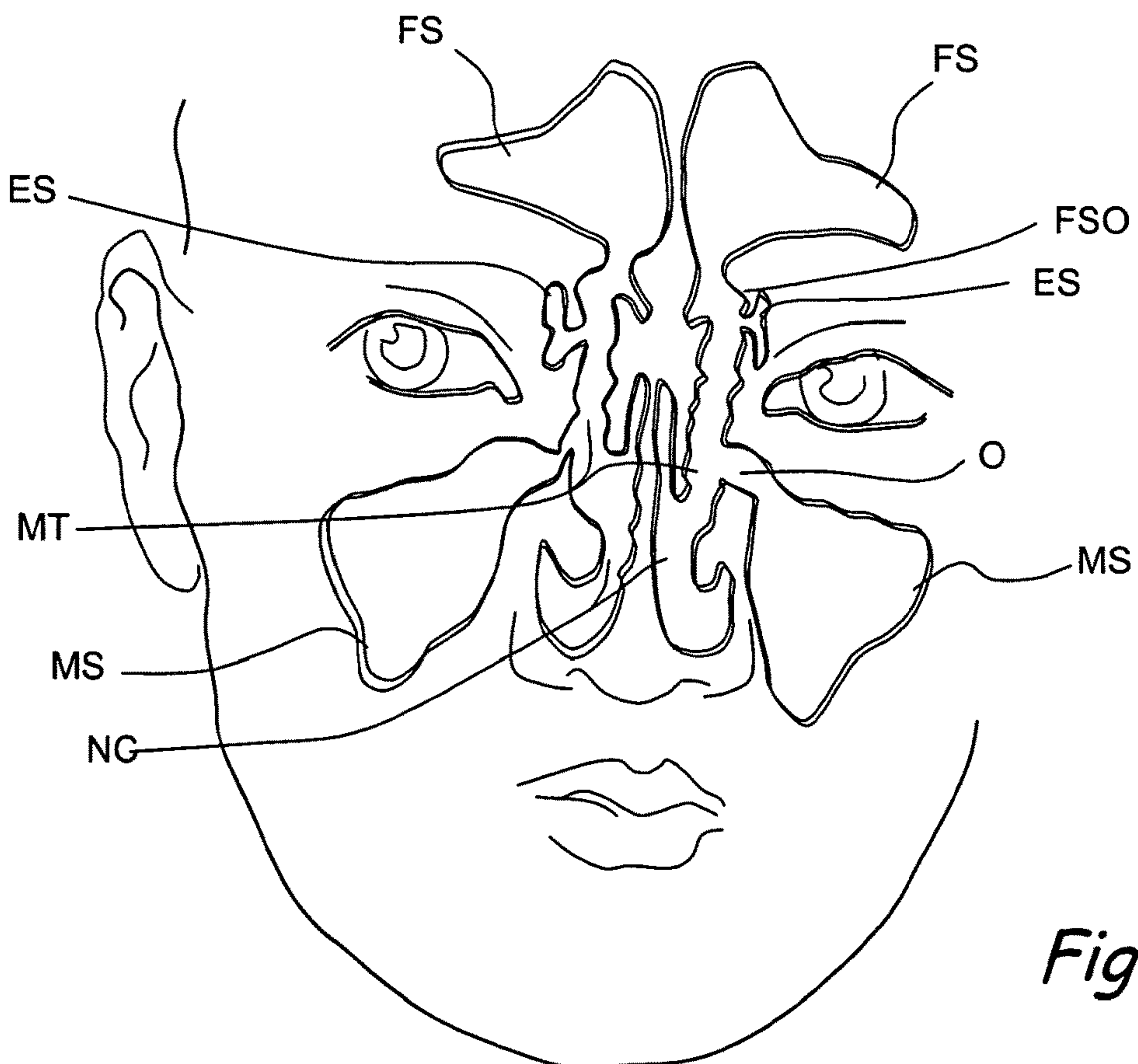


Fig. 7 E

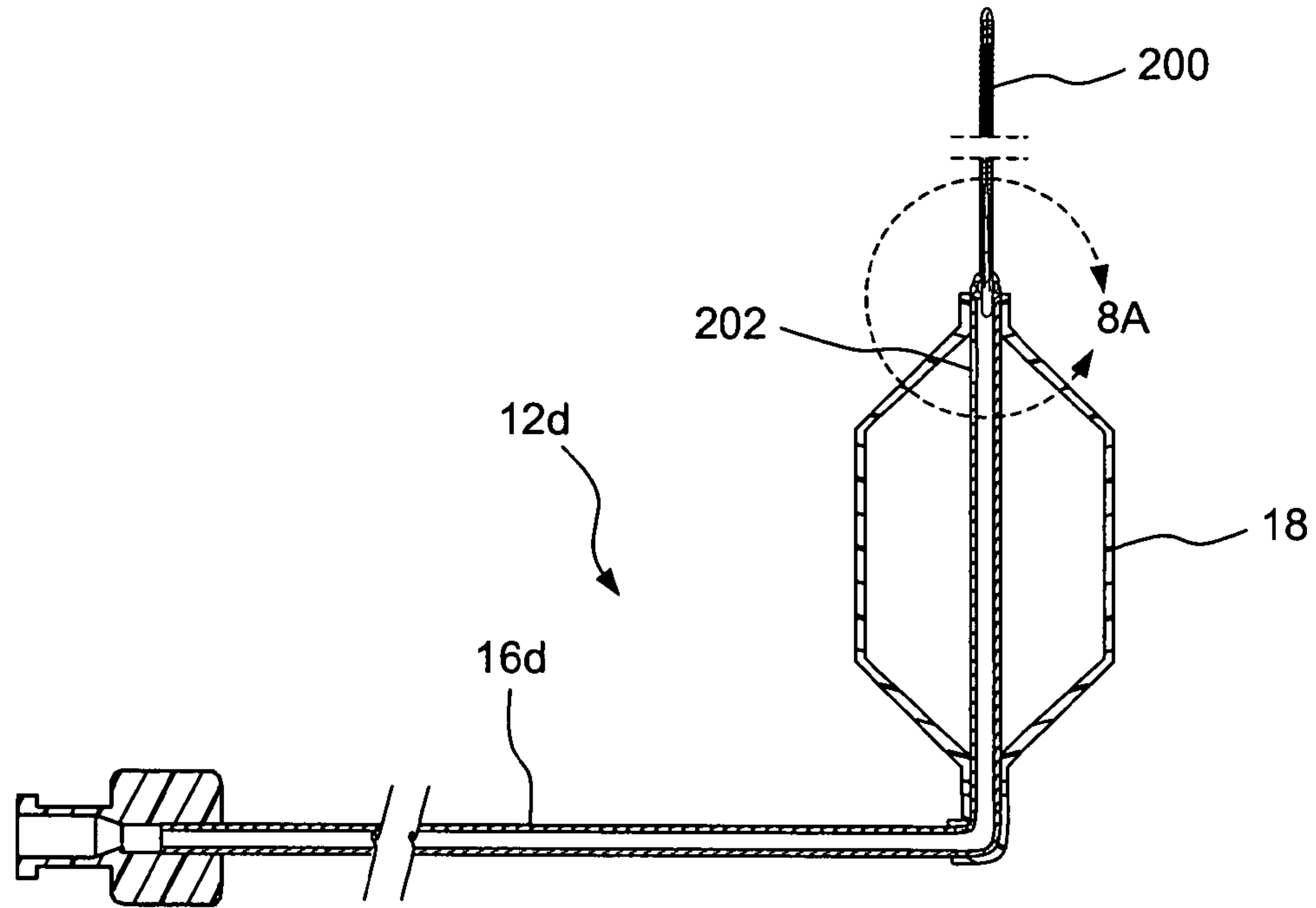


Fig. 8

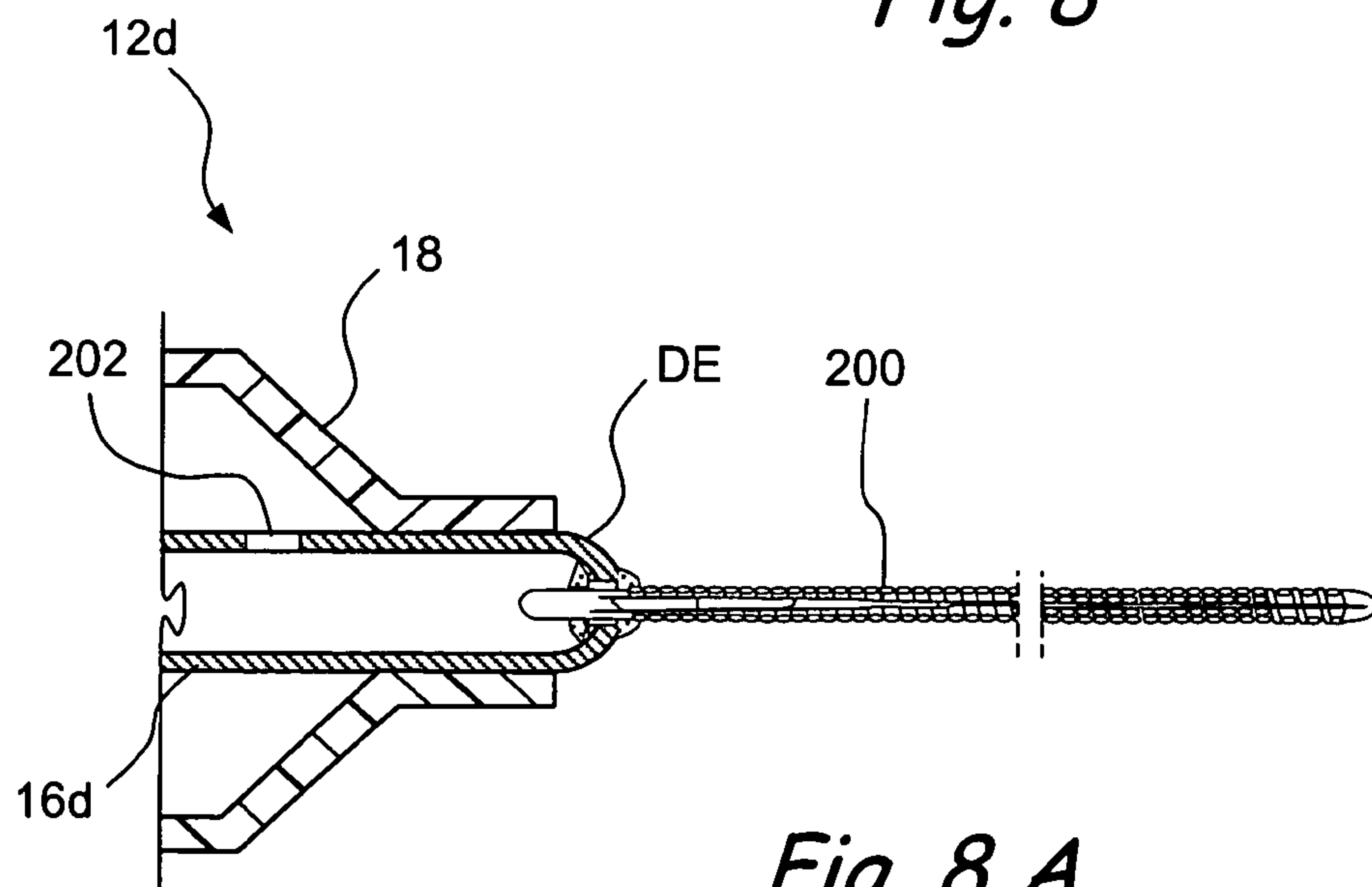


Fig. 8 A

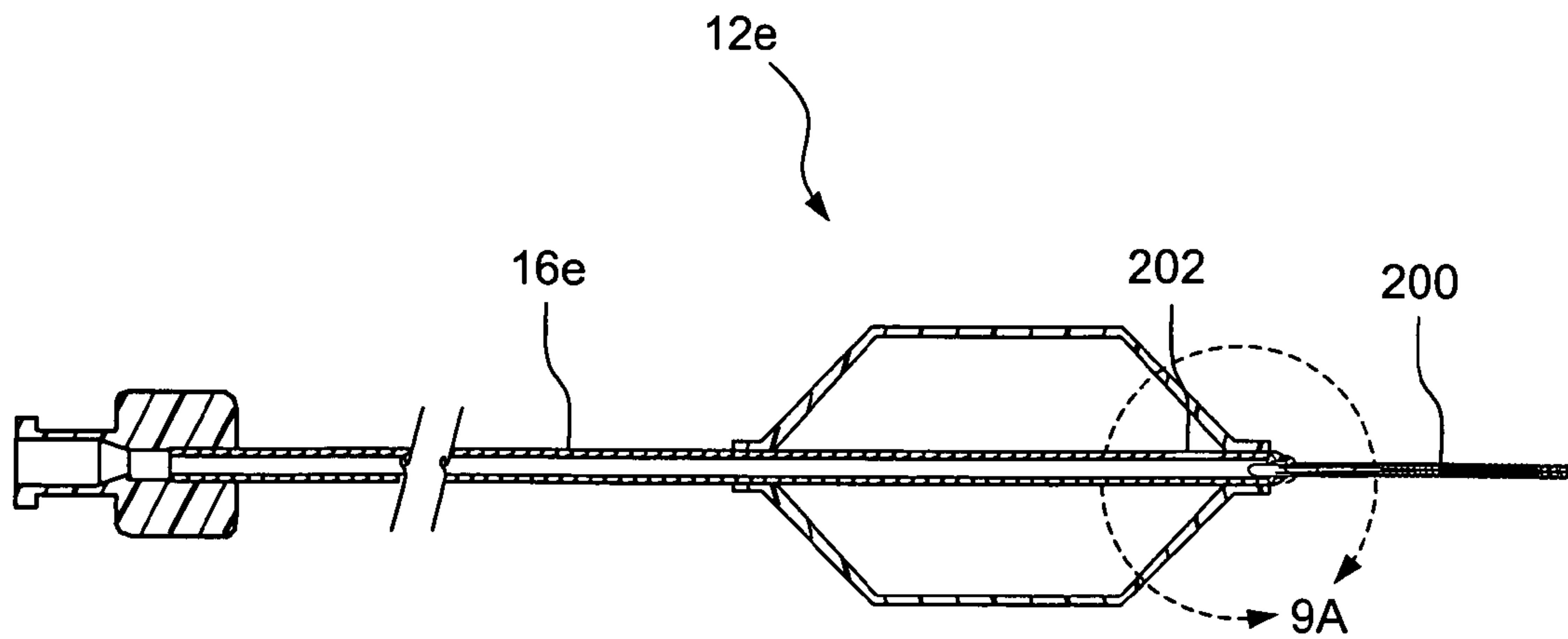


Fig. 9

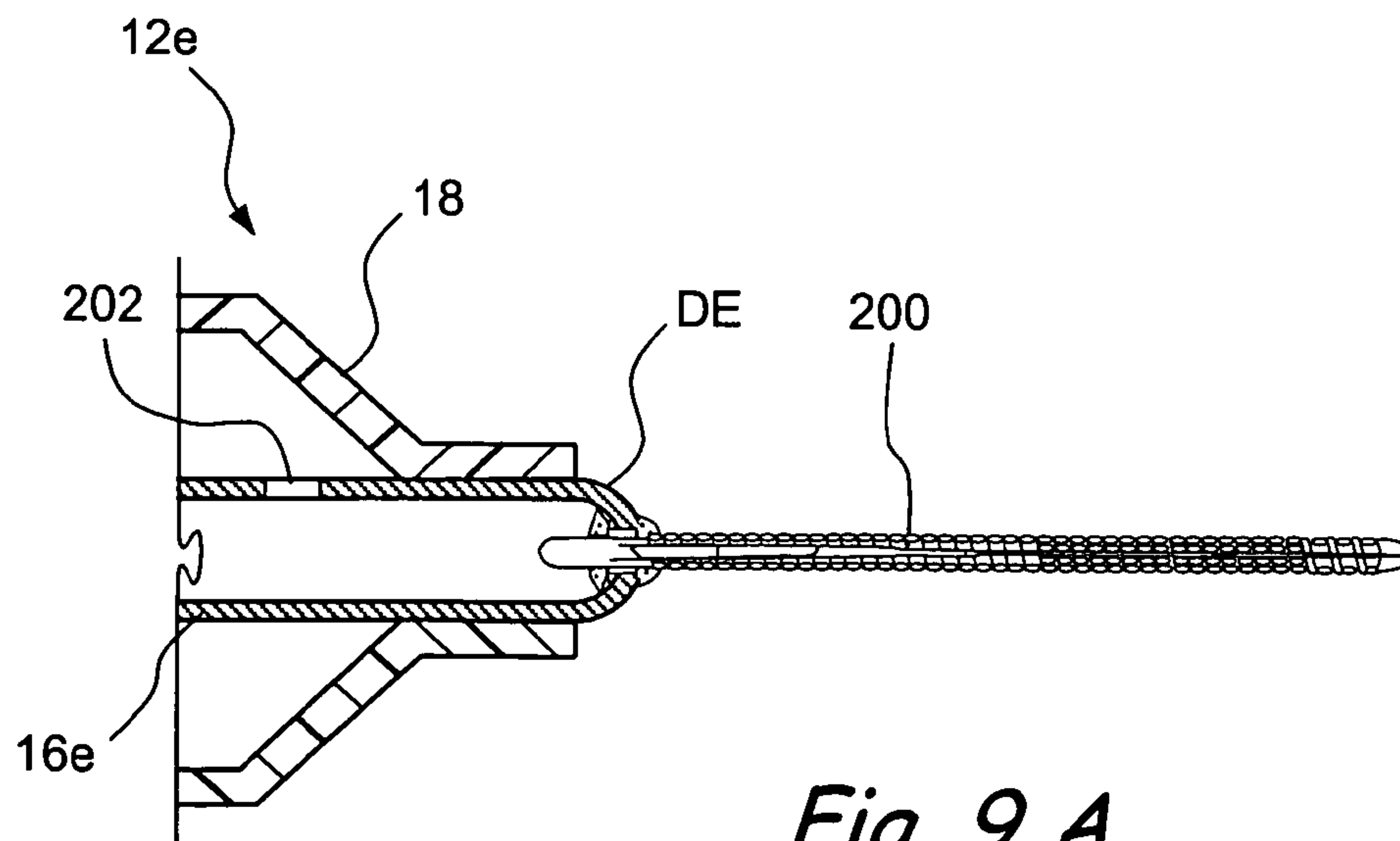


Fig. 9 A

**CATHETERS WITH NON-REMOVABLE
GUIDE MEMBERS USEABLE FOR
TREATMENT OF SINUSITIS**

RELATED APPLICATION

The present application is a continuation of U.S. application Ser. No. 14/567,051 entitled "Catheters with Non-Removable Guide Members Useable for Treatment of Sinusitis," issued as U.S. Pat. No. 10,124,154 on Nov. 13, 2018, which is a continuation of U.S. application Ser. No. 11/438,090 entitled "Catheters with Non-Removable Guide Members Useable for Treatment of Sinusitis," issued as U.S. Pat. No. 8,951,225 on Feb. 10, 2015, which is a continuation-in-part of U.S. application Ser. No. 11/193,020 entitled "Methods and Apparatus for Treating Disorders of the Ear, Nose and Throat," now abandoned. U.S. Pat. No. 11/438,090 is also a continuation-in-part of U.S. patent application Ser. No. 11/150,847 entitled "Devices, Systems and Methods Useable for Treating Sinusitis" filed Jun. 10, 2005, issued as U.S. Pat. No. 7,803,150 on Sep. 28, 2010, the entire disclosure of which is expressly incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to medical devices and methods and more particularly to minimally invasive, devices, systems and methods for treating sinusitis and other ear, nose & throat disorders.

BACKGROUND

Balloon angioplasty catheters have been used to treat cardiovascular disorders for many years. In general, balloon angioplasty catheters of the prior art have included over-the-wire catheters, which ride over a separate guide wire, which represent the majority of balloon catheters, fixed-wire catheters, which combine the balloon catheter and guide wire into one device, and rapid exchange catheters, which are essentially over-the-wire type catheters with short guide-wire lumens that allow the catheter to be exchanged without the use of an extension wire.

The fixed wire balloon angioplasty catheters of the prior art have typically ranged in length from about 120 cm to about 150 cm and have had balloon dimensions and flexural properties that were suitable for performing balloon angioplasty procedures in coronary or peripheral blood vessels. Examples of commercially available fixed-wire balloon angioplasty catheters include the Ace™ balloon catheters (Boston Scientific, Inc., Natick, Mass.).

More recently, procedures have been developed wherein balloon catheters are used to dilate the ostia (or other openings) of paranasal sinuses for the treatment of disorders such as sinusitis. In these procedures, a balloon catheter or other dilator catheter is advanced transnasally into an opening of a paranasal sinus and used to dilate that opening, thereby improving drainage and ventilation of the affected sinus. In some embodiments, a guide catheter is initially inserted into the nose, a guidewire is then advanced through the guide catheter and the balloon catheter is then advanced over the guidewire. In other embodiments, as described in parent application U.S. patent application Ser. No. 11/150,847, issued as U.S. Pat. No. 7,803,150, the balloon catheter may be equipped with a non-removable guide member that extends from its distal end and is advanceable through the ostium of the paranasal sinus ahead of the catheter shaft and

balloon. The provision of such non-removable guide member extending from the distal end of the balloon catheter eliminates the need for use of a separate guidewire, thereby simplifying the procedure, shortening the procedure time, reducing the need for an assistant, and decreasing the amount of radiation exposure to the patient and operator due to use of fluoroscopy.

There remains a need in the art for further development and refinement of balloon catheters (and other dilator devices) that have non-removable guide members for use in dilating the ostia of paranasal sinuses.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a balloon catheter device for dilating an opening of a paranasal sinus in a human or animal subject. In general, this balloon catheter device comprises; (a) a catheter shaft having a proximal end and a distal end, (b) a non-compliant or semi-compliant balloon (or other suitable dilator) mounted on the catheter shaft, such balloon being positionable within the opening of the paranasal sinus while in a non-inflated state and thereafter inflatable to an inflated state such that it will cause dilation of the opening of the paranasal sinus, (c) at least one position indicating element useable to determine when the balloon is positioned within the opening of the paranasal sinus and (d) a non-removable guide member, at least a portion of which extends from the distal end of the catheter shaft, said non-removable guide member having a limited range of axial movement or no movement relative to the catheter shaft, said non-removable guide member being advanceable through the opening of the paranasal sinus ahead of the catheter shaft. Such balloon catheter device has a length less than about 20 cm. In some embodiments, the guide member may be attached to the catheter device in a substantially fixed position. In other embodiments, the guide member may be attached to the catheter device in a manner that allows the guide member to undergo rotational movement and/or some limited range of longitudinal movement (e.g., axial translation). In some embodiments the guide member may extend through all or part of the catheter shaft, with only a portion of the guide member protruding beyond the distal end of the catheter shaft. In other embodiments, the guide member may be attached to the distal end of the catheter shaft such that little or no part of the guide member actually extends into the catheter body. In some embodiments, the catheter shaft may be formed of plastic while in other embodiments the catheter shaft may be formed of metal (e.g., hypotube). In some embodiments, the catheter device may be used in conjunction with a straight or curved guide catheter. In other embodiments, the catheter device may be inserted into the opening of a paranasal sinus without the use of a guide catheter.

Further in accordance with the invention there is provided a guide catheter through which the above-summarized balloon catheter device may be inserted. Such guide catheter may comprise an outer metal tube and a plastic tube that extends coaxially through the lumen of the metal tube with a distal portion of the plastic tube extending out of and beyond the distal end of the metal tube. The portion of the plastic tube that extends beyond the distal end of the metal tube may be straight or curved. In some embodiments, an outer cover may extend over all or part of the outer surface of the guide catheter and such outer cover may serve to smooth the transition between the distal end of the metal tube and the adjacent surface of the protruding portion of the

plastic tube. In some embodiments, an inner liner (e.g., a lubricious liner) may line all or part of the lumen of the inner plastic tube.

Still further in accordance with the present invention, there is provided a method for dilating an opening of a paranasal sinus in a human or animal subject. This method generally comprises the steps of; (A) providing a balloon catheter that has a non-removable guide member that extends from its distal end, (B) trans-nasally inserting the balloon catheter and causing at least part of the non-removable guide member to pass through an opening of the paranasal sinus, (C) moving the balloon catheter to a location where the balloon is positioned within the opening of the paranasal sinus and (D) inflating the balloon to cause dilation of the opening of the paranasal sinus.

Further aspects, details and embodiments of the present invention will be understood by those of skill in the art upon reading the following detailed description of the invention and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a side view of a guide catheter/non-removable wire balloon catheter system of the present invention.

FIG. 1A is a side view of the non-removable wire balloon catheter shown in FIG. 1.

FIG. 1B is a side view of the guide catheter shown in FIG. 1.

FIG. 2 is a cross sectional view through the longitudinal axis of the non-removable wire balloon catheter of FIG. 1A.

FIG. 2A is a cross sectional view through line 2A-2A of FIG. 2.

FIG. 2B is a cross sectional view through line 2B-2B of FIG. 2.

FIG. 2C is a cross sectional view through line 2C-2C of FIG. 2.

FIG. 2D is a cross sectional view through line 2D-2D of FIG. 2.

FIG. 2E is cross sectional view through the longitudinal axis of an alternative embodiment of a non-removable wire balloon catheter of the present invention.

FIG. 2F is cross sectional view through the longitudinal axis of yet another alternative embodiment of a non-removable wire balloon catheter of the present invention.

FIG. 3 is a partially sectioned side view of the non-removable guidewire component included in the balloon catheters shown of FIGS. 1A, 2E and 2F.

FIG. 4 is a partial longitudinal sectional view through a balloon catheter of the present invention showing an alternative construction at the location where the proximal end of the balloon is mounted on the outer catheter shaft.

FIG. 5A is another side view of the guide catheter of FIG. 1B, with the catheter rotated 90 degrees from that seen in FIG. 1B.

FIG. 5B is a cross sectional view through line 5C-5C of FIG. 5A.

FIG. 5C is an enlarged view of region 5C of FIG. 5B.

FIG. 5D is an enlarged cross sectional view through Line 5D-5D of FIG. 5B.

FIG. 5E is an enlarged view of region 5E of FIG. 5B.

FIG. 5F is an enlarged view of region 5F of FIG. 1B.

FIG. 5G is a cross sectional view through line 5G of FIG. 5A.

FIGS. 6A and 6B are schematic diagrams showing a device and method for forming the curve in the guide catheter of FIG. 1B.

FIGS. 7A-7E show steps in a method for using the system of FIG. 1 to enlarge the ostium of a maxillary sinus in a human subject.

FIG. 8 is a cross sectional view through a longitudinal axis of another embodiment of a non-removable wire balloon catheter, having a curved hypotube shaft.

FIG. 8A is an enlarged view of a distal portion of FIG. 8.

FIG. 9 is a cross sectional view through a longitudinal axis of another embodiment of a non-removable wire balloon catheter, having a straight hypotube shaft.

FIG. 9A is an enlarged view of a distal portion of FIG. 9.

DETAILED DESCRIPTION

The following detailed description and the accompanying drawings are intended to describe some, but not necessarily all, examples or embodiments of the invention. The contents of this detailed description and the accompanying drawings do not limit the scope of the invention in any way.

The term "opening of a paranasal sinus" as used herein shall, unless otherwise stated, include any and all trans-nasally accessible opening in a paranasal sinus or air cell including but not limited to; natural ostia, surgically altered natural ostia, surgically created openings, antrostomy openings, ostiotomy openings, burr holes, drilled holes, ethmoidectomy openings, natural or man made passageways, etc.

The term "diagnostic or therapeutic substance" as used herein is to be broadly construed to include any feasible drugs, prodrugs, proteins, gene therapy preparations, cells, diagnostic agents, contrast or imaging agents, biologicals, etc. Such substances may be in bound or free form, liquid or solid, colloid or other suspension, solution or may be in the form of a gas or other fluid or nan-fluid. For example, in some applications where it is desired to treat or prevent a microbial infection, the substance delivered may comprise pharmaceutically acceptable salt or dosage form of an antimicrobial agent (e.g., antibiotic, antiviral, antiparasitic, antifungal, etc.), a corticosteroid or other anti-inflammatory (e.g., an NSAID), a decongestant (e.g., vasoconstrictor), a mucous thinning agent (e.g., an expectorant or mucolytic), an agent that prevents or modifies an allergic response (e.g., an antihistamine, cytokine inhibitor, leucotriene inhibitor, IgE inhibitor, immunomodulator), etc. Other non-limiting examples of diagnostic or therapeutic substances that may be useable in this invention are described in copending U.S. patent application Ser. No. 10/912,578 entitled Implantable Devices and Methods for Delivering Drugs and Other Substances to Treat Sinusitis and Other Disorders filed on Aug. 4, 2004, issued as U.S. Pat. No. 7,361,168 on Apr. 22, 2008, the entire disclosure of which is expressly incorporated herein by reference.

The term "nasal cavity" as used herein shall, unless otherwise stated, be broadly construed to include any cavity that is present in the anatomical structures of the nasal region including the nostrils and paranasal sinuses.

The term "trans-nasal" as used herein shall mean through a nostril.

In general, FIGS. 1-5H show catheters devices of the present invention, FIGS. 6A and 6B show a device and method for forming a curve in a guide catheter device of the present invention and FIGS. 7A-7E show one embodiment of a method for using catheter devices of the present invention to treat sinusitis in a human subject.

With reference to FIGS. 1-2D, one embodiment of a system 10 of the present invention comprises a non-removable wire balloon catheter 12 and a guide catheter 14. Although shown and described as a system it is to be

appreciated that the non-removable wire balloon catheter **12** and guide catheter **14** need not necessarily be used in combination, but rather may also be used independently of one another.

Non-Removable Wire Balloon Catheter

The embodiment of the non-removable wire balloon catheter **12** shown in FIGS. 1-2E comprises an elongate, flexible catheter shaft **16** having a balloon **18** mounted thereon. A proximal Luer hub **20** is attached to the proximal end of the catheter shaft **16**. An inflation device (not shown) may be attached to the Luer hub **20** and used to inflate and deflate the balloon **18**. A non-removable guide member **22** extends out of and beyond the distal end DE of the catheter shaft **16**.

In one preferred embodiment for adult applications, balloon catheter **12** has an overall length of approximately 43.5 cm and its shaft **16** has an outer diameter of about 0.058 inches.

As seen in FIG. 2, in this embodiment, the catheter shaft **16** comprises an outer tube **30** which extends from the hub **20** through the proximal end **32** of balloon **18**. An inner tube **34** is positioned coaxially within the outer tube **30** and extends from the mid-region of the outer tube **30** and through the distal end of the balloon **36**. As shown, the proximal end of the balloon **32** is attached by adhesive, thermal bonding or other suitable means to the outer surface of the outer tube **30** and the distal end of the balloon **36** is attached by adhesive, thermal bonding or other suitable means to the outer surface of the inner tube **34**. The balloon has a cylindrical sidewall with tapered portions adjacent to the proximal end **32** and distal end **36**. The length of the cylindrical portion of the balloon **18** is referred to herein as the balloon's working length WL. The working length WL of balloon **18** may, in some embodiments, range from 4 mm to 35 mm. In one preferred embodiment, the working length of the balloon is around 16 mm \pm 1 mm. In another preferred embodiment, the working length of the balloon is around 24 mm \pm 1 mm. Balloon **18** may be inflated to a suitable working pressure of around 12 to 16 atmospheres.

Optionally, position indicators, such as radiopaque markers **38**, **40** may be mounted on the inner tube **34** within the balloon **18** to mark the locations of the proximal and distal ends of the working length WL. Balloon **18** may be coated with one or more balloon coatings including, but not limited to puncture resistance coating, abrasion resistance coating, anti-tack coating, lubricous, hydrophilic, etc. In a particular embodiment, balloon **18** is made of PET of a wall thickness around 0.001 inches coated by a 0.001 inch thick polyurethane coating with a tensile strength of 12,000 to 16,000 psi and a burst pressure of more than 16 atmospheres. In some embodiments, a portion of the non-removable guide member **22** may extend through the balloon **18** and that portion of the non-removable guide member **22** may be radiopaque or otherwise radiographically distinguishable from the rest of the non-removable guide member **22** so as to indicate the position of balloon **18** as well as the position of the non-removable guide member distal end.

As seen in FIGS. 2 and 3, the non-removable guide member **22** of this embodiment extends fully through the catheter shaft **16** such that only a portion of this guide member **22** protrudes beyond the distal end of the catheter shaft **16**. The guide member **22** is constructed to impart differing degrees of stiffness to different regions of the catheter shaft **16**. In this regard, as may be best appreciated from FIG. 3, the guide member **22** generally comprises a proximal portion or region **60**, a middle portion or region **62** and a distal portion or region **64**. This guide member **22** is

constructed of a core wire **66**, an outer coil **68** and an inner coil **70**. In some embodiments, the core wire may be of constant diameter over its entire length. However, in the example shown, the core wire **66** has sections of differing diameter and, hence, differing stiffness. In this example, a proximal section **68** of core wire **66** makes up the proximal region **60** of guide member **22** and is of uniform constant diameter, typically in the range of 0.014 mm to 0.038 in some embodiments and of 0.025 \pm 0.0005 inch in other embodiments. The particular diameter and/or rigidity of this proximal portion or region **60** may be selected to provide sufficient support to the balloon while remaining small enough to reduce shaft profile and inflation and deflation time of the balloon.

Within the middle region **62** of the guide member **22**, the core wire **66** has a number of stepped down areas, namely a first tapered section **72**, a first constant diameter section **74** of uniform constant diameter (e.g., in the range of 0.006 to 0.012 inches), a second tapered section **76** and a second constant diameter section **78** of uniform constant diameter (e.g., in the range of 0.002 to 0.008 inches). The distal region **78** of constant diameter may have some or all of its length flattened or partially flattened to fine tune the distal flexibility of the guidewire. The guidewire should be very flexible near the proximal end of region **64** to enable the guidewire to conform to the internal contours of the sinus anatomy. In some embodiments, this distal section **80** of the core wire **66** may be flattened (e.g., cut, swaged, etc.) while the remaining portions of the core wire **66** may be substantially round. In embodiments where the distal section **70** of the core wire **66** is flattened, the height of the flat is generally between from about 0.001 inch to about 0.004 inch. Such flattening of the distal section **70** of the core wire **66** accomplishes the purpose of making the distal region **64** more flexible in one plane (e.g., up and down) than in another plane (e.g., side to side), thereby rendering the distal portion **64** more likely to form a smooth curl within the sinus cavity as it is advanced through the sinus opening.

An outer helical coil, such as a stainless steel wire coil, is affixed to the first tapered section **72** within the middle region **62** and extends to the distal tip of the guide member **22**. An inner helical coil, platinum/tungsten alloy, is disposed within the outer coil **70** and around part of the distal section **80** of the core wire **66**, as shown. This construction forms an atraumatic tip that is sufficiently stiff to pass through the nasal and paranasal anatomy and floppy enough to buckle without causing damage to the nasal and paranasal tissue. The platinum/tungsten alloy provides a radiopaque marker to identify the tip of the non removable guide member **22** when viewed fluoroscopically.

Two design parameters, namely the diameters and/or relative stiffness of the various sections **68**, **72**, **74**, **76**, **78**, **80** and material of which the core wire **66** is constructed, can be of particular importance in allowing the non-removable guide member **22** to achieve its desired function. In the preferred embodiment, core wire **66** is made of nickel-titanium alloy (Nitinol) which has high elasticity. The high elasticity of the nickel-titanium core wire **66** enables the balloon catheter shaft **16** to pass easily through regions of guide catheter **14** that have sharp bends or curves without kinking of the core wire **66**. The constant diameter section **74** is the region where the balloon is located. The diameter of this section should be small enough to avoid creating excessive stiffness which would create resistance when advancing the balloon catheter through the tip of the guide catheter. However, the diameter of region **74** must be large enough to prevent guidewire buckling and support the

balloon as the catheter is advanced. Most importantly, the diameter of region 74 and the gradual taper of region 76 must allow the guidewire to bend in a relatively smooth arc without kinking where the non removable guide member 22 exits the distal end of the balloon 18. In one embodiment the optimal diameter of constant diameter section 74 has been determined to be between 0.006 to 0.012 inches. This diameter can be used to develop catheters for various sinus anatomies and locations. For instance, a catheter designed to extend a significant distance out the tip of a relatively straight guide could use a larger diameter. A catheter for use in a shaped guide needs a smaller diameter to reduce resistance through the guide. The length of non-removable guide member 22 extending out the distal end of the balloon 18 should be long enough to partially define the outline of the sinus cavity when viewed fluoroscopically but not so long that an excessive length of guidewire tip must be advanced into small sinus cavities. In a preferred embodiment, the length is between about 3 cm and about 6 cm.

The proximal end of the outer tube 30 is received within hub 20 and an outer sleeve 44 may be formed about the area where the outer tube 30 enters the hub 20. Labeling may be printed on this sleeve 44 and, optionally, this sleeve 44 may act as a strain relief member.

As seen in FIGS. 2 and 2D, a crimpable member such as a metal hypotube 48 is attached to the proximal end of section 68 of core wire 66 and extends into the hub 20, where it is surrounded by a plastic hypotube cover 50. The hypotube 48 is crimped inwardly so as to frictionally engage and hold the proximal section 68 of core wire 66 within hub 20. As seen in the cross section view of FIG. 2D, the hypotube 48 may be crimped at discrete locations so as to provide flow channels 90 through which balloon inflation fluid may flow.

As shown in FIG. 1A, a short distal marker 116 and a long proximal marker 118 may be formed on the catheter shaft 16. Distal marker 116 and long proximal marker 118 enable the user to determine the relative location of various regions of balloon catheter device 12 relative to the distal tip of guide catheter 14 without requiring the use of fluoroscopy. For example, the distal marker 116 may be approximately 1.5 mm long and long proximal marker 118 may be approximately 20 mm long. Also, the distal end of distal marker 116 may be located approximately 127 mm from the distal tip of guide member 22 and the proximal end of long proximal marker 93 may be located approximately 131 mm from the proximal end of the balloon 18. These markers 116, 118 are useable in various ways. For example, as described more fully herebelow, the balloon catheter 12 may be useable in conjunction with a specially sized guide catheter 14 as seen in FIG. 1B. In typical usage, the distal end of the non-removable guide member 22 will be inserted into the proximal Luer hub 108 of guide catheter 14 and the balloon catheter 12 will be advanced through the guide catheter 14. The balloon catheter 12 may be sized relative to the guide catheter 14 such that, when the distal marker 116 is even with and about to enter the proximal end of the Luer hub 108 of guide 14, the distal end DE of non-removable guide member 22 will be even with and about to emerge out of the distal end DE of guide catheter 14. Also, when the proximal end of long proximal marker 118 is even with the Luer hub 108 of guide 14, the end of the balloon 36 will be even with and about to emerge out of the guide catheter 14. Also, when the proximal end of long proximal marker 118 is even with and about to enter the proximal end of the Luer hub 108 of guide 14, the proximal end of the balloon 32 will be even

with the distal end of the guide catheter 14 and the entire balloon 18 will have emerged out of the distal end of the guide catheter 14.

In embodiments where the balloon catheter 12 is to be inserted through a curved guide catheter 14, it may be desirable to design the proximal joiner of the balloon 18 to the catheter shaft 16 in such a way as to minimize the likelihood for snagging or catching of the proximal end 32 of the balloon 18 as the balloon catheter 14 is pulled back through the curved portion of the guide. FIGS. 2E and 2F show alternative embodiments of the balloon catheter 10a, 10b which are designed to accomplish this. Also, FIG. 4 shows an alternative construction of the catheter shaft 16 at the location where the proximal balloon end 32 is affixed to the catheter shaft 16.

The balloon catheter 10a shown in FIG. 2E is the same as that shown in FIG. 2, except that in the catheter 10a of FIG. 2E the balloon 18A is formed in the distal portion of an elongated balloon tube member 90 which extends proximally to a location near the middle of the catheter shaft where it is bonded to outer tube 30. In this manner, the seam between the proximal end of balloon tube member 90 and outer tube 30 is located proximally enough to avoid any passing through (or being retracted through) the curved region of the guide catheter 14.

The balloon catheter 10b shown in FIG. 2F is the same as that shown in FIG. 2 except that in the catheter 10b of FIG. 2F, the outer tube 30 is absent and an elongated balloon tube 92 extends all the way to the proximal end of the catheter body where it is received within the sleeve 44 and is bonded to hypotube 48. In this manner, the catheter body is essentially seamless from the balloon 18n all the way proximal to the hub 20, thereby eliminating any potential for a seam to snag or catch on the curvature in the guide catheter 14.

With reference to FIG. 4, in some embodiments of the catheter device 10 such as that shown in FIGS. 1-2D, a modified outer tube 30a may be used wherein the outer diameter of such outer tube 30a is reduced at the location where the proximal end 32 of the balloon 18 is affixed, thereby providing a smoothed transition and deterring the proximal end 32 of balloon 18 from snagging or catching as it is retracted through a curved guide catheter or the like.

Guide Catheter

An example of the preferred guide catheter 14 is shown in FIGS. 2B and 5A-5G. As shown, the guide catheter 14 comprises an elongate shaft 102. Guide catheter 14 is made of suitable biocompatible materials as described below. The distal portion of the shaft 102 incorporates a curve 101. Various embodiments of guide catheter 14 may be designed with unique curves formed therein to access specific anatomical locations. Or, in some embodiments, the guide catheter shaft 102 may be malleable so that the operator may form the shaft 102 to a desired shape prior to or during the procedure. In another embodiment (not shown), the guide catheter 14 shaft may be straight, without any curvature. Guide catheters 14 having different angles A of curve 101 may be used, for example, to access one or more anatomical regions in the nasal cavity including, but not limited to ostia of various paranasal sinuses.

In the example shown in the drawings, the elongate shaft 102 of the guide catheter 14 is formed of an outer metal tube such as a hypotube 114 having a plastic tube 112 extending coaxially therethrough with a distal portion 100 of the plastic tube 112 protruding out of and beyond the distal end of the hypotube 114, as seen in FIG. 5F. The hypotube in this example is traditional stainless steel hypotube material. However, it will be appreciated that this hypotube 114

element may be formed of any suitable material having the desired stiffness, such as stainless steel, titanium, nickel-titanium alloys (e.g., Nitinol), polymers such as Nylon, etc. The plastic tube **112** formed of suitable material such as Nylon or other thermoplastic. In the embodiment shown, the radius of curvature of the curve **101** is 0.18 inches. In the embodiment shown, the outer diameter of the flared distal end of elongate shaft **102** is 0.113+/-0.003 inches and the length of radiopaque marker is 0.04 inches. The length of atraumatic tip **104** ranges from 0.060 to 0.120 inches. The outer rim of atraumatic tip **104** is radiused. The distal end of outer sleeve **106** is tapered as shown and covers elongate shaft **102**. In a preferred embodiment shown, the outer diameter of the distal end of outer sleeve **106** is 0.109+/-0.003 inches.

Optionally, an outer sleeve or cover **106** may be disposed over a portion of the outer surface of hypotube **114** and, in some cases, may extend over at least some of the protruding distal portion **100** of the plastic tube **112**, thereby providing a smooth outer surface over the area where the distal end of the hypotube **114** is located. Such outer sleeve or cover **106** may be formed of any suitable material such as Nylon or other heat shrinkable thermoplastic.

Also optionally, an inner liner **111** may extend through and line the wall of the lumen of plastic tube **112**. This inner liner **111** may be formed of any suitable material, and preferably a lubricious material, such as polytetrafluoroethylene PTFE or the like.

In a preferred embodiment, guide device **14** is of a smaller outer diameter than has been previously known for trans-nasal treatment of paranasal sinuses. The construction of the embodiment allows for greater access and less trauma to a larger number of patient's sinuses, particularly the maxillary sinuses. The smaller diameter allows for the use of the guide catheter alongside other instruments, like an endoscope, in the constricted paranasal anatomy. A shorter or more compact tip allows for greater maneuverability in the tortuous and constricted anatomy. The smaller diameter of the guide allows easier, less traumatic passage in the paranasal cavities. For example, it is easier to fit between the nasal septum and the middle turbinate when accessing the sphenoid; easier fit into the middle meatus and between the lateral wall of the middle turbinate and the uncinate process and lamina paprycia when accessing the maxillary, frontal, and ethmoid sinuses; easier to fit in the middle meatus and up into the frontal recess when accessing the frontal sinus. Additionally, the tight/small diameter of the distal curve of the guide allows less damage/trauma to the middle turbinate and uncinate when accessing the maxillary sinus. When the guide is torqued such that the curve of the guide (the plane of the curve) is essentially perpendicular to the middle turbinate and uncinate process, it will be easier to fit a smaller curve in that narrow space between the middle turbinate and the uncinate/infundibulum. Additionally, when accessing the maxillary sinus, the smaller diameter guide tip (not curvature radius, but actual diameter of the tip) is better able to slip behind the uncinate (or between the uncinate and lateral wall) and then access the maxillary sinus. With a larger guide catheter, it is not uncommon for the surgeon to tease forward the uncinate process because he was not able to slip the bigger guide catheter tip behind the uncinate process. It is especially useful in accessing the maxillary sinus where the guide catheter tip must be advanced in one orientation to pass by the middle turbinate and then rotated to "hook" the distal end around the uncinate process to give access to the maxillary ostium. In the preferred embodiment, the outer cover **106** is made of a

length of Nylon 11 tubing with an inner diameter of 0.125+/-0.001 inches and an outer diameter of 0.139+/-0.001 inches. Outer cover **106** substantially surrounds the outer surface of the hypotube and a region of elongate shaft **102** emerging from the distal end of the hypotube after it is fused/laminated to these underlying surfaces. The final diameter of the shaft over the hypo tube region is 0.134+/-0.003". This embodiment comprising outer cover **106** is especially useful for providing an outer lubricious surface on guide device **14**, for improving joint integrity between the hypotube and elongate shaft **102**, and creating a smooth transition between the distal portion of elongate shaft **102** and the distal end of the hypotube. The proximal end of guide device **14** comprises a hub **108**. In the embodiment shown, hub **108** is a female Luer hub. The portion of outer cover **106** extending beyond the distal end of hub **108** is covered with a length of label tubing **110** as shown. The length of label tubing **110** may range from 0.5 inches to 1 inch. In an embodiment where the guide catheter **14** has a curve **101** of 110 degrees and is intended for use in accessing a maxillary sinus, the label tubing **110** may be labeled with the code "M-110", wherein the "M" stands for maxillary sinus and the "110" stands for the angle of the curved region **101**. The length of the portion of the guide device **14** that enters the body may range preferably from 3 inches to 5 inches, and the length of the portion that remains outside of the body is preferably at least 0.5 inches. The overall length of guide device **14** measured from the distal end of hub **108** to the distal tip of guide device **14** measured along a curved distal region of elongate shaft **102** is 4.25+/-0.25 inches. The length of guide device measured from the proximal end of hub **108** to the distal tip of guide device **14** measured along a curved distal region of elongate shaft **102** is 5.16+/-0.15 inches. The inner surface of guide device **14** may be lined by a lubricious coating or a tubular lubricious liner (not shown). Such a lubricious coating or tubular lubricious liner is useful to facilitate passage of one or more devices through the lumen of guide device **14** especially when guide device **14** comprises an angled, curved or bent region. Proximal portion of guide device **14** may comprise a rotating valve device (not shown) such as a Touhy-Borst device to lock down a device such as a sheath, guidewire, balloon catheter or other devices that are being inserted through guide device **14**. The distal region of guide device **14** disclosed has a radiopaque marker **120** (see FIGS. **5E** and **5F**). The radiopaque marker may be made of suitable biocompatible materials including, but not limited to, metals, polymers loaded with a radiopaque substance, etc. In one embodiment, multiple guide devices **14** of varying designs are provided in a kit.

FIG. **5B** shows a longitudinal sectional view of the guide device **14**. The outer diameter of elongate shaft **102** is around 0.113+/-0.001 inches and the inner diameter of elongate shaft **102** is around 0.095+/-0.001 inches prior to being fused/laminated to the underlying tubing. In a preferred embodiment, the material of elongate shaft **102** has Rockwell hardness in the range of about 70R to about 110R. In this preferred embodiment, the distal portion of elongate shaft **102** is flexible enough to prevent or reduce damage to the anatomy. Yet, the distal portion is rigid enough to retain its shape as one or more devices are passed through guide device **14**. Furthermore, the distal portion of elongate shaft **102** is rigid enough to enable a user to use the distal portion to displace paranasal structures. The distal portion of elongate shaft **102** comprises a curved or angled region **101** curved at an angle ranging from 0 degrees to 135 degrees. In a preferred embodiment, the inner surface of elongate

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shaft **102** is lined by a lubricious coating or a tubular lubricious liner **112** made of a suitable biocompatible material such as PTFE. In one embodiment, the inner diameter of lubricious liner **112** in guide device **14** is 0.087+/-0.003 inches. In one embodiment, lubricious liner **111** is made from a PTFE tube of outer diameter 0.093+0.0/-0.001 inches and an inner diameter of 0.089+/-0.001 inches which shrinks to about 0.087+/-0.003 inches upon bonding to inner surface of the elongate shaft **102**. A radiopaque marker **120** (shown in FIG. 1F) is located in the distal region of elongate shaft **102** between plastic tube **112** and lubricious liner **112**. The liner **111** extends beyond the distal end of plastic tube **112** and underlying marker **120** and the atraumatic tip member **104** is disposed about and secured to the distal end of the liner **111**, as seen in the enlarged view of FIG. 5E. The atraumatic tip **104** may be formed of suitable biocompatible materials including, but not limited to a polyether block amide (Pebax 40D). Atraumatic tip **104** prevents or reduces accidental damage to the anatomy caused by the distal tip of guide device **14**. In one embodiment, length of atraumatic tip **104** ranges from 0.060 to 0.120 inches. The material of atraumatic tip **104** can have a Shore Durometer hardness in the range of about 35D to about 72D. Guide device **14** further comprises a hypotube **114** to which elongate shaft **102** and outer cover **106** are attached. In a preferred embodiment, the outer diameter of hypotube **114** is 0.120+/-0.001 inches and the inner diameter is 0.112+/-0.002 inches. In a preferred embodiment of guide device **14**, no portion of hypotube **114** is exposed to bodily fluids. In one embodiment of a method of constructing guide device **14**, a stainless steel hypotube **114** is bonded to an elongate shaft **102** such as a Nylon tube to increase the strength of elongate shaft **102**. In one embodiment of bonding hypotube **114** to elongate shaft **102**, hypotube **114** is heat bonded to elongate shaft **102**. One or more openings, perforations or holes may be located on hypotube **114** to enable material of elongate shaft **102** to melt into the one or more openings, perforations or holes. When the melted material of elongate shaft **102** solidifies, an additional mechanical bonding is created between hypotube **114** and elongate shaft **102**. In another embodiment of bonding hypotube **114** to elongate shaft **102**, hypotube **114** is bonded to elongate shaft **102** by an adhesive. The proximal end of guide device **14** comprises hub **108**. In the embodiment shown, hub **108** is a female luer hub. In a preferred embodiment, the luer taper on such a female luer hub conforms to ISO 59471-1986 and ISO 59472-1991. Hub **108** may be attached to the outer surface of outer sleeve **106**. In one embodiment, hub **108** is attached to the outer surface of outer sleeve **106** by a suitable biocompatible adhesive e.g. Dymax 1191. Hub **108** has two wings to enable a user to turn guide device **14**. In a preferred embodiment, the two wings are located in the same plane as the plane of a curve on the distal region of elongate shaft **102** to assist the user in knowing where the tip of guide device **14** is pointing. In another embodiment, one wing can be longer than the other or have another indicia of which side of the device the curved tip of located. The guide device design shown in FIGS. 1A-1C is especially suited for trans-nasal access of the maxillary sinuses.

In a preferred embodiment, the length of atraumatic tip **104** ranges from 0.060 to 0.120 inches. The outer and/or inner rim of the distal end of atraumatic tip **104** may be radiused to reduce or eliminate sharp edges which in turn reduces or minimizes injury to tissue during the use of guide device **14**. In one embodiment, the radius of curvature of the radiused outer and/or inner rim ranges from 0.005 to 0.012

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inches. In a preferred embodiment, the tubular element is made of Pebax 40D and has an outer diameter ranging from 0.115+/-0.001 inches and an inner diameter ranging from 0.095+/-0.001 inches. Atraumatic tip **104** is fused to shaft **102** to form a butt joint. The tubular element is preferably designed using a suitable material of construction and a suitable manufacturing process such that there is negligible color bleeding from atraumatic tip **104**. The distal end of guide device **14** also comprises a radiopaque marker **120**. In the embodiment shown, radiopaque marker **120** is located between the distalmost region of elongate shaft **102** and lubricious liner **112**. In one embodiment of guide device **14**, no portion of radiopaque marker **120** is exposed to bodily fluids. Radiopaque marker **120** may be made of suitable biocompatible materials including, but not limited to, metals, polymers loaded with a radiopaque substance, etc. In one embodiment, radiopaque marker **120** comprises a platinum marker band of a length of 0.040+/-0.003 inches. The platinum marker band has an outer diameter of 0.096+/-0.001 inches and an inner diameter of 0.092+/-0.0005 inches. In the embodiment shown, the outer diameter of the flared distal end of elongate shaft **102** is 0.113+/-0.003 inches and the length of radiopaque marker is 0.04 inches. The length of atraumatic tip **104** ranges from 0.060 to 0.120 inches. The outer rim of atraumatic tip **104** is radiused. The distal end of outer sleeve **106** is tapered as shown and covers part of the protruding distal portion **101** of plastic tube **112**. In a preferred embodiment shown, the outer diameter of the distal end of outer sleeve **106** is 0.109+/-0.003 inches.

The distal end of atraumatic tip **104** is designed to be as close to the distal end of radiopaque marker **120** as possible to minimize the length of atraumatic tip **104**. In one embodiment of a method of manufacturing guide device **14**, a PTFE tube that forms lubricious liner **112** is slid inside elongate shaft **102** made of Nylon. The distal end of elongate shaft **102** is flared to create an annular space between the flared distal end of elongate shaft **102** and lubricious liner **112**. Thereafter, a platinum marker band that forms radiopaque marker **120** is slid over the PTFE tube into the annular space between the distal end of elongate shaft **102** and lubricious liner **112**. Radiopaque marker **120** is attached to elongate shaft **102** and lubricious liner **112** by a suitable adhesive. Examples of such adhesives include, but are not limited to Loctite™ 4011, etc. A Pebax tube that forms atraumatic tip **104** is slide over lubricious liner **112** such that the Pebax tube abuts against the distal end of elongate shaft **102**. A suitable heat shrink tubing is inserted over guide device **14**. The distal end of guide device **14** is heated. This fuses the Pebax tube to elongate shaft **102** and also fuses the Pebax tube to lubricious liner **112**. Thereafter, the distal end of the Pebax tube may be trimmed. One advantage of this embodiment of a method of manufacturing guide device **14** is a strong bond between elongate shaft **102** made of Nylon and the Pebax tube that forms atraumatic tip **104**. Another advantage of this embodiment of a method of manufacturing guide device **14** is that the distal most region of the Pebax tube that forms atraumatic tip **104** may be trimmed as close to the distal end of the platinum marker band to minimize the length of atraumatic tip **104**. Such embodiments comprising a short atraumatic tip **104** enable easier navigation and/or torquing and/or repositioning of the distal tip of guide device within the paranasal anatomy with less injury to the patient.

FIG. 5C shows an enlarged view of the proximal portion of the guide device **14** and FIG. 5G shows a cross section through the shaft **102**. As shown, in this example the shaft **102** of the guide device **14** comprises an inner liner **111** surrounded by plastic tube **112** which in turn is surrounded

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by hypotube **114** which in turn is surrounded by outer sleeve **106**. In the embodiment shown, hub **108** is attached to the outer surface of outer sleeve **106** by a suitable biocompatible adhesive e.g. Dymax 1191. Hub **108** comprises a hub lumen **118** that is in fluid communication with the lumen enclosed by lubricious liner **112**. Hub **118** may be designed such that the transition between hub lumen **118** and the lumen enclosed by lubricious liner **112** is smooth. This allows a seamless transition from hub lumen **118** to the lumen enclosed by lubricious liner **112**.

FIG. 5D shows a sectional view of the guide device through the tapered transition portion of the shaft **102** at the distal end of hypotube **114**. As shown, in this example, the distal end of hypotube **114** terminates proximal to the distal end of plastic tube **112** and outer sleeve **106** covers the distal end of the hypotube **114** and tapers to a reduced outer diameter at its distal end, thereby providing a smooth outer surface over the distal end of hypotube **114**. In this example, the length of the tapered region of outer cover **106** creates a smooth transition between the distal end of hypotube **114** and the protruding distal portion **101** of plastic tube **112**.

Method and Device for Manufacture of the Guide Catheter

In one embodiment of a method of introducing a curve in elongate shaft **102** of guide device **14**, the guide device is gradually bent while a polymeric region of the guide device is heated to a temperature greater than the temperature at which the polymeric region softens. For example, FIGS. 2A and 2B show the steps of a method of introducing an angle or curve in a guide device. FIG. 2A shows a partial sectional view through a bending device **122** comprising a shaping component **124** and a gripping component **126**. Shaping component **124** comprises a curved region that defines the final radius of the angled or curved region of guide device **14**. In one embodiment, bending device **122** is designed to detachably attach one of multiple shaping components **124** wherein each shaping component **124** has a unique shape. A suitable sized beading **128** is introduced through the lumen of guide device **14** as shown in FIG. 2A. Beading **128** is sized such that the outer diameter of beading **128** is slightly smaller than the diameter of the lumen of guide device **14**. In a preferred embodiment, beading **128** is made of PTFE. Thereafter, a heat shrinkable tubing **130** is introduced over guide device **14** and beading **128**. Heat shrinkable tubing **130** may be made of suitable polymers including, but not limited to Fluorinated Ethylene-Propylene (FEP), PTFE, PFA, ETFE, MFA, THV, etc. Thereafter, a region of the combination of guide device **14**, beading **128** and heat shrinkable tubing **130** is fixed to bending device **122**. In the embodiment shown in FIG. 2A, a region of the combination of guide device **14**, beading **128** and heat shrinkable tubing **130** is fixed to bending device **122** by a spring grip **132** attached to gripping component **126**. A region of guide device **14** to be bent is heated. This region of guide device **14** may be heated by convection or radiation. In one method embodiment, the region of guide device **14** to be bent is heated by blowing hot air on the region of guide device **14** to be bent. The hot air may be generated by a hot box. The temperature of the hot air ranges from 320 to 360 degrees F. In another method embodiment, the region of guide device **14** to be bent is heated by radiant heat generated from an electrical heater. Thereafter, the region of guide device **14** to be bent is bent as shown in FIG. 2B by applying a suitable mechanical bending force. In this embodiment, the region of guide device **14** to be bent was bent after heating the region of guide device **14** to be bent. In an alternate embodiment,

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the region of guide device **14** to be bent was heated while bending the region of guide device **14** to be bent. After bending the region of guide device **14** to be bent, guide device **14** is cooled. Guide device **14** is removed from bending device **122**. Heat shrinkable tubing **130** and beading **128** are removed from guide device **14**.

Various design parameters of the guide devices disclosed herein may be defined for quality control of the guide devices. Such parameters may include size parameters, shape parameters, tensile force parameters, etc. In one example, guide device **14** is designed to have a bond of tensile strength of 15 N between hub **108** and outer sleeve **106**. In another example guide device **14** is designed to have a bond of tensile strength of 15 N between atraumatic tip **104** and elongate sheath **102**. In another example, guide device **14** is designed to withstand a torque of 0.048 N-m applied by torquing hub **108** relative to the straight region of guide device **14** distal to label tubing **110**. The applied torque of 0.048 N-m should not cause kinking or failure of the bond between outer sleeve **106** and hypotube **114** or the bond between hub **108** and outer sleeve **106**.

Guide device **14** may be used for introducing one or more devices into the anatomy. Examples of such devices include, but are not limited to, over-the-wire balloon catheters, fixed wire balloon catheters, rapid-exchange balloon catheters, guidewires, etc. Guide device **14** may also be used for applying suction to or providing lavage to an anatomical region.

It is to be appreciated that the non-removable guide member **22** need not necessarily extend through or into the catheter shaft **16** and the catheter shaft **16** need not necessarily be formed of flexible plastic. For example, FIGS. 8-9A show balloon catheter devices **12d**, **12e** having a curved tubular metal shaft **16d** (FIGS. 8-8A) or a straight tubular metal shaft **16e** (FIGS. 9-9A) with a balloon **18** mounted thereon. An opening **202** is formed in the wall of the tubular shaft **16d**, **16e** to permit inflation fluid to be infused into or extracted from the balloon **18**. A non-removable guide member **200** attached to and extends from the distal end DE of the metal shaft **16d**, **16e**. In this example, the non-removable guide member **200** does not extend substantially into or through the shaft **16d**, **16e** as in the embodiments described above. Rather, in this embodiment, the non-removable guide member **200** is attached to and extends distally from the distal end DE of the shaft **16d**, **16e**, as shown. This non-removable guide member **200** may be attached to the shaft **16d**, **16e** by soldering, welding, adhesive, threaded connection, crimping of the shaft, frictional engagement, or any other suitable connection technique. Examples of catheters having this type of construction (but lacking the non-removable guide member **22a**) include those described in United States Patent Application Publication No. 2004/0064150A1, issued as U.S. Pat. No. 8,317,816 on Nov. 27, 2012 (Becker), the entire disclosure of which is expressly incorporated herein by reference.

Method for Dilating the Ostium of a Maxillary Sinus

FIGS. 7A-7E show steps in one example of a method for using the system **10** of FIG. 1 to dilate the ostium O of a maxillary sinus MS in a human subject. Anatomical structures in FIGS. 7A-7E are labeled as follows:

A number of the drawings in this patent application show anatomical structures of the ear, nose and throat. In general, these anatomical structures are labeled with the following reference letters:

- Nasal Cavity NC
- Frontal Sinus FS
- Frontal Sinus Ostium FSO

Ethmoid Sinus ES
 Sphenoid Sinus SS
 Medial Turbinate MT
 Maxillary Sinus MS
 Uncinate Process UP

Initially, as shown in FIG. 7A, the guide catheter **14** is inserted trans-nasally, advanced through the nasal cavity NC and positioned such that its distal end is adjacent to the ostium O of the maxillary sinus MS.

Thereafter, as shown in FIG. 7B, the balloon catheter **12** is inserted through the guide catheter **14** causing the distal portion of the non-removable guide member **22** to pass through the ostium and into the cavity of the maxillary sinus MS.

Then, as seen in FIG. 7C, the balloon catheter **14** is further advanced until the entire portion of the non-removable guide member **22** that protrudes beyond the distal end of the catheter shaft **16** is curled within the maxillary sinus MS and the balloon **18** has exited the distal end of the guide catheter **14** and is positioned within the ostium O. The positioning of the balloon within the ostium O may be verified by direct visualization, endoscopically and/or radiographically, as described elsewhere in this patent application.

Thereafter, as shown in FIG. 7D, the balloon **18** is inflated one or more times causing the ostium O to dilate.

Finally, as shown in FIG. 7E, the balloon is deflated and the balloon catheter **12** and guide catheter **14** are removed. In some cases, the guide catheter **14** may be allowed to remain in place after removal of the balloon catheter **12** and a lavage fluid, other substance or one or more other devices (e.g., lavage catheters, balloon catheters, cutting balloons, cutters, chompers, rotating cutters, rotating drills, rotating blades, sequential dilators, tapered dilators, punches, dissectors, burs, non-inflating mechanically expandable members, high frequency mechanical vibrators, dilating stents and radiofrequency ablation devices, microwave ablation devices, laser devices, snares, biopsy tools, scopes and devices that deliver diagnostic or therapeutic agents) may be passed through the guide catheter for further treatment of the condition.

Although the methods and devices disclosed herein are illustrated in conjunction with particular paranasal sinuses, it is understood that these methods and devices can be used in other paranasal sinuses as well as other anatomical passageways of the ear, nose or throat, such as Eustachian tube, larynx, and choana.

Optionally, any of the working devices and guide catheters described herein may be configured or equipped to receive or be advanced over a guidewire or other guide member (e.g., an elongate probe, strand of suture material, other elongate member) unless to do so would render the device inoperable for its intended purpose. Some of the specific examples described herein include guidewires, but it is to be appreciated that the use of guidewires and the incorporation of guidewire lumens is not limited to only the specific examples in which guidewires or guidewire lumens are shown. The guidewires used in this invention may be constructed and coated as is common in the art of cardiology. This may include the use of coils, tapered or non-tapered core wires, radiopaque tips and/or entire lengths, shaping ribbons, variations of stiffness, PTFE, silicone, hydrophilic coatings, polymer coatings, etc. For the scope of this invention, these wires may possess dimensions of length between 5 and 75 cm and outer diameter between 0.005" and 0.050".

Several modalities can be used with the devices and methods disclosed herein for navigation and imaging of the

devices within the anatomy. For example, the devices disclosed herein may comprise an endoscope for visualization of the target anatomy. The devices may also comprise ultrasound imaging modalities to image the anatomical passageways and other anatomical structures. The devices disclosed herein may comprise one or more magnetic elements especially on the distal end of the devices. Such magnetic elements may be used to navigate through the anatomy by using external magnetic fields. Such navigation may be controlled digitally using a computer interface. The devices disclosed herein may also comprise one or more markers (e.g. infra-red markers). The markers can be used to track the precise position and orientation of the devices using image guidance techniques. Several other imaging or navigating modalities including but not limited to fluoroscopic, radiofrequency localization, electromagnetic, magnetic and other radiative energy based modalities may also be used with the methods and devices disclosed herein. These imaging and navigation technologies may also be referenced by computer directly or indirectly to pre-existing or simultaneously created 3-D or 2-D data sets which help the doctor place the devices within the appropriate region of the anatomy.

It is to be appreciated that the invention has been described herein with reference to certain examples or embodiments of the invention but that various additions, deletions, alterations and modifications may be made to those examples and embodiments without departing from the intended spirit and scope of the invention. For example, any element or attribute of one embodiment or example may be incorporated into or used with another embodiment or example, unless to do so would render the embodiment or example unsuitable for its intended use. Also, where the steps of a method or process are described, listed or claimed in a particular order, such steps may be performed in any other order unless to do so would render the embodiment or example un-novel, obvious to a person of ordinary skill in the relevant art or unsuitable for its intended use. All reasonable additions, deletions, modifications and alterations are to be considered equivalents of the described examples and embodiments and are to be included within the scope of the following claims.

What is claimed is:

1. A method of dilating an opening within a nose, ear, or throat of a human or animal subject, said method comprising the steps of:

(A) providing a balloon and a non-removable guide member, wherein the balloon comprises a distal end, wherein the balloon defines a longitudinal axis, wherein the non-removable guide member extends distally from the distal end of the balloon, wherein the non-removable guide member is configured to bend relative to the longitudinal axis of the balloon;

(B) inserting a distal portion of the non-removable guide member to pass through the opening within the nose, ear, or throat;

(C) moving the balloon to a location where the balloon is positioned within the opening within the nose, ear, or throat; and

(D) inflating the balloon to cause dilation of the opening within the nose, ear, or throat.

2. The method of claim **1**, wherein the inserting a distal portion of the non-removable guide member to pass through the opening within the nose, ear, or throat further comprises inserting the distal portion of the non-removable guide member to pass through an ostium of a paranasal sinus.

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3. The method of claim 2, wherein the inserting the distal portion of the non-removable guide member to pass through an ostium of a paranasal sinus further comprises inserting the distal portion of the non-removable guide member to pass through the ostium of a maxillary sinus.

4. The method of claim 2, wherein prior to the performance of steps B-D, a guide catheter having a distal end is inserted trans-nasally and positioned adjacent to the opening of the paranasal sinus.

5. The method of claim 4, wherein Step B further comprises inserting the non-removable guide member to pass through the opening of the paranasal sinus.

6. The method of claim 1, wherein the inserting a distal portion of the non-removable guide member to pass through the opening within the nose, ear, or throat further comprises inserting the distal portion of the non-removable guide member to pass through the opening into a Eustachian tube.

7. The method of claim 1, wherein the inserting a distal portion of the non-removable guide member to pass through the opening within the nose, ear, or throat further comprises inserting the distal portion of the non-removable guide member to pass through the opening into a larynx.

8. The method of claim 1, wherein the inserting a distal portion of the non-removable guide member to pass through the opening within the nose, ear, or throat further comprises inserting the distal portion of the non-removable guide member to pass through the opening into a choana.

9. The method of claim 1, wherein providing the non-removable guide member further comprises providing a non-removable guide member comprising a guidewire.

10. The method of claim 9, wherein providing the guidewire further comprises providing a core wire and an outer coil.

11. The method of claim 10, wherein providing the guidewire further comprises providing an inner coil.

12. The method of claim 10, wherein providing the core wire further comprises providing a proximal portion, a distal portion, and a tapered portion between the proximal portion and the distal portion.

13. The method of claim 1, wherein providing the balloon further comprising a providing an elongated flexible catheter shaft attached to the balloon.

14. The method of claim 13, wherein providing the balloon and elongated flexible catheter shaft further comprises providing a proximal luer hub attached to the elongated flexible catheter shaft.

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15. The method of claim 13, wherein providing the balloon and elongated flexible catheter shaft further comprises providing a marker attached to the elongated flexible catheter shaft.

16. A method of dilating an opening within a nose, ear, or throat of a human or animal subject, said method comprising the steps of:

(A) providing a device comprising a balloon and a guidewire non-removably attached to the balloon, wherein the guidewire extends distally from a distal end of the balloon, wherein the balloon defines a longitudinal axis, wherein the guidewire is configured to bend relative to the longitudinal axis of the balloon;

(B) inserting a distal portion of the guidewire to pass through the opening within the nose, ear, or throat;

(C) moving the balloon to a location where the balloon is at least partially positioned through the opening within the nose, ear, or throat; and

(D) inflating the balloon to cause dilation of the opening within the nose, ear, or throat.

17. The method of claim 16, wherein providing the device further comprises an elongated flexible catheter shaft attached to the balloon.

18. The method of claim 17, wherein providing the device further comprises a luer in fluid communication with the balloon.

19. A method of dilating an opening within a nose, ear, or throat of a human or animal subject, said method comprising the steps of:

(A) providing a balloon and a flexible guidewire non-removably attached to the balloon, wherein the flexible guidewire extends distally from a distal end of the balloon, wherein the balloon defines a longitudinal axis;

(B) inserting a distal portion of the flexible guidewire to pass through the opening within the nose, ear, or throat;

(C) moving the balloon through the opening within the nose, ear, or throat to a desired location; and

(D) inflating the balloon to cause dilation of the opening within the nose, ear, or throat.

20. The method of claim 19, wherein providing the flexible guidewire further comprises providing the flexible guidewire comprising an inner core and an outer coil.

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